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United States
Department of
Agriculture

Forest Service
Southern Region

Draft Environmental Impact Statement
VEGETATION MANAGEMENT in the Ozark/Ouachita Mountains
VOLUME I

Management Bulletin R8-MB 23

June 1989

READEX
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COMMENTS ON THE METRIC SYSTEM

The metric system is used to describe weights and measures. It is a decimal system -- units are consistantly named to reflect multiplication or division of the basic unit by some power of 10 (10, 100, 1000, etc.). The two basic defined units of this system are the meter and the kilogram. All other units (volume, area, etc.) are calculated based on these two.

Metric measurement is the standard for scientific communication worldwide. It has been selected in preference to many other systems including the English system of measures which is in common use in the United States. Below is a table which will help readers of this Risk Assessment understand the metric numbers presented throughout the text.

ABBREVIATIONS
(Metric and English)

ac = acre
cc = cubic centimeter
cm = centimeter
ft = foot
g = gram
ha = hectare
in = inch

kg = kilogram
km = kilometer
l = liter
lb = pound
m = meter
mg = milligram
mi = mile

ml = milliliter
mm = millimeter
ppm = parts per million
oz = ounce
qt = quart
um = micrometer

CONVERSIONS

Length:

METRIC to ENGLISH
1 km (1,000 m) == 0.6214 mi
1 m == 39.37 in
1 cm (.01m) == 0.394 in
1 mm (.001m) == 0.0394 in
1 um (.000001m) == 0.000039 in

ENGLISH to METRIC
1 mi == 1.609 km
1 ft == 0.305 m
1 in == 2.54 cm

Mass / Weight:

1 kg (1,000 g) == 2.2046 lb
1 g == 0.035 oz
1 mg (.001 g) == 0.000035 oz
1 ug (.000001 g) = 0.000000035 oz

1 lb == 453.592 g
1 oz == 28.35 g

Others:

1 l == 1.056 qt (liquid)
1 ha == 2.471 ac
1 kg/ha == 0.89 lb/ac

1 qt == 1.136 l
1 ac == 0.40 ha
1 lb/ac == 1.12 kg/ha

INVITATION TO REVIEW THE DRAFT EIS

Dear Reader:

Here is the Draft Environmental Impact Statement (DEIS) for Vegetation Management on National Forests of the Ozark/Ouachita Mountains area. During June 1988, we asked for your suggestions on issues. Interested individuals helped us identify 5 issues, and we would appreciate your help in reviewing the Draft EIS.

We have examined eight alternatives which represent a range of possible approaches to vegetation management (one proposes no action). The preferred alternative is alternative F. All alternatives reflect our effort to address issues you identified. They propose programs that:

- Consider effects from intensive site-disturbing methods.
- Minimize the effects of herbicides to people, wildlife, and the environment, and allow aerial application (alternatives G and H).
- Achieve desired objectives for other resource outputs, while promoting habitat conditions for a variety of plant and animal species and enhancing conditions for recovery of threatened, endangered, or sensitive species.
- Reduce risk of injury to workers using manual methods.
- Enhance visual quality along right-of-way corridors emphasizing timing of activities and promoting flowering vegetation.

The Draft EIS and appendices are bound separately. If you did not receive both and wish to have them, please contact me and I will immediately send you whatever you need.

As you begin your review and prepare to comment, let me suggest some things that will assist your review.

- If you're interested in a quick look at the entire process and results, read the summary beginning on page 1.
- Each chapter begins with a very brief outline of what information is contained in the chapter and how it is organized.

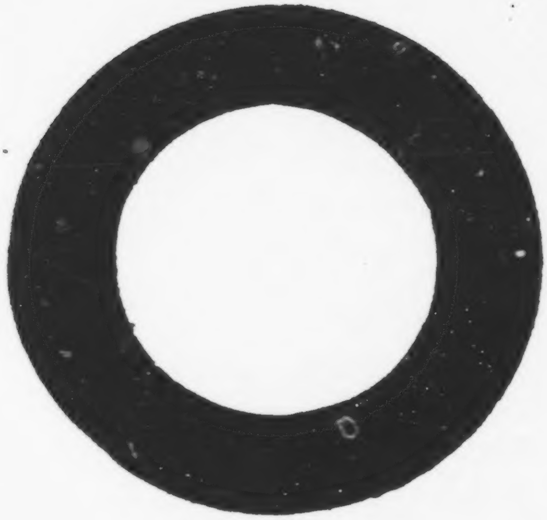
Remember, for us to be able to use your comments, you need to respond by the due date. To assist you, we have provided a postage-paid response form on the next page. Our address is listed on the cover sheet of this document and is also on the response form. We're looking forward to your review and comment.

Sincerely,

Steve McCorquodale

STEVE MCCORQUODALE
Leader, Vegetation Management EIS Team

June 14, 1989



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RESPONSE FORM

We're providing this form to make it convenient for you to respond. You need not use this form though.

However you decide to respond, please help us by making specific and meaningful comments. Have we done an adequate scientific analysis? Do the Alternatives respond to your concerns?

Comments on Scientific Analysis:

Why?

Fold

Comments on Alternatives:

Why?

Other:

Fold

Why?

(use additional sheets as necessary)

To return this comment sheet, fold and staple with USDA Forest Service address outside and drop in the mail (no postage necessary).

Name: First MI Last (Organization)

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DRAFT Environmental Impact Statement for

VEGETATION MANAGEMENT

in the Ozark/Ouachita Mountains

USDA Forest Service
Southern Region | Arkansas and Oklahoma

Responsible Agency	Responsible Official	Information Contact
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Comments Must Be Received By: September 7, 1989

Abstract

This environmental impact statement presents eight alternative ways to manage vegetation on Ozark/Ouachita Mountains national forests of the USDA Forest Service's Southern Region. These alternatives range from no treatment to maximum vegetation control. Treatment alternatives use different mixes of methods and vary numbers of acres treated so as to present a wide array of possible approaches. Effects of each alternative on the physical and biological environment and on social and economic conditions are presented. Alternative F is the Forest Service's preferred alternative. Comments must be received by: September 7, 1989

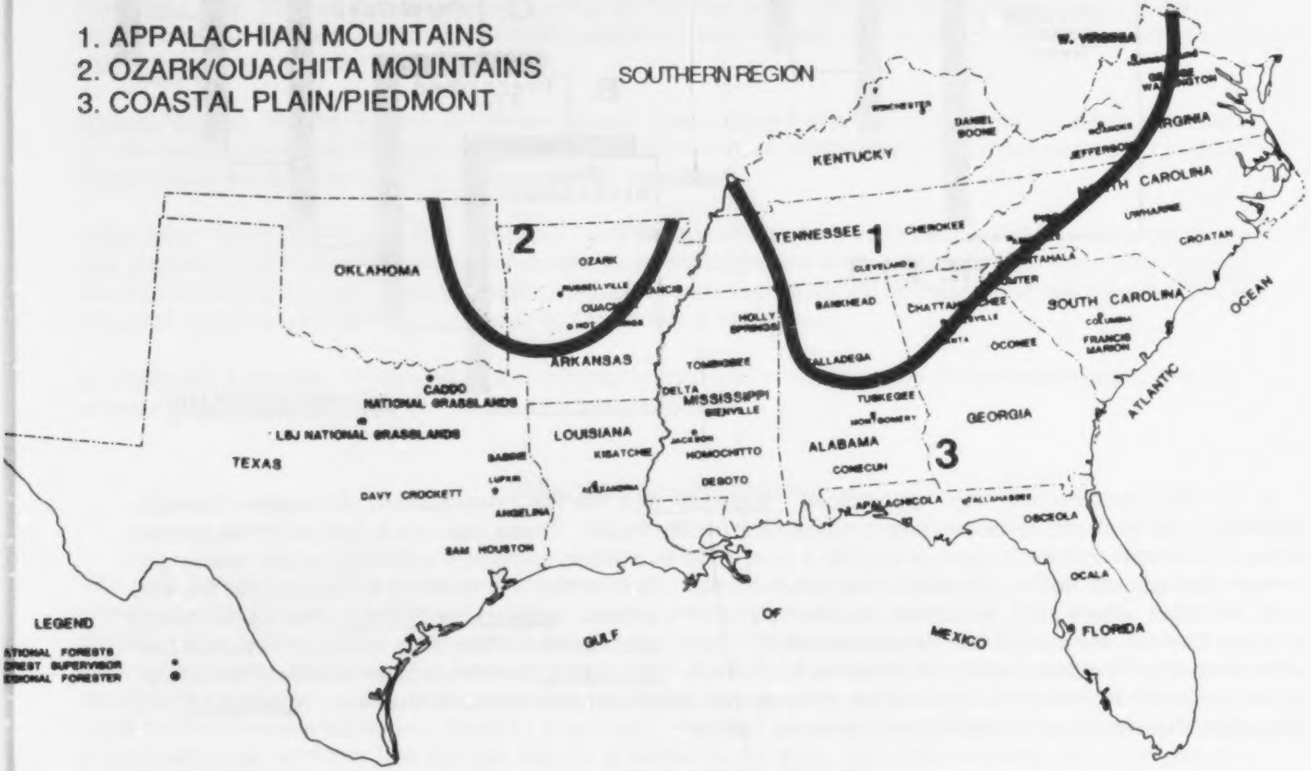
Note to Reviewers

Reviewers should provide the Forest Service with comments during the review period. This will enable the Forest Service to analyze and respond to comments at one time and to use the information to prepare the final environmental impact statement, thus avoiding undue delay in the decision-making process. Reviewers have an obligation to structure their participation in the National Environmental Policy Act process so that it is meaningful and alerts the agency to reviewers' positions and contentions, Vermont Yankee Nuclear Power Corp. V. NRDC, 435 U.S. 519, 553 (1978). Environmental objections that could have been raised at the draft stage may be waived if not raised until after completion of the final environmental impact statement, Wisconsin Heritages, Inc. v. Harris, 490 F. Supp. 1334, 1338 (E.D. Wis. 1980). Comments should be specific and should address the adequacy of the statement or merits of the alternatives discussed.

SUMMARY

Introduction

This summary is an introduction to the Environmental Impact Statement (EIS) for vegetation management on national forests in the Ozark/Ouachita Mountains. This area includes all of Arkansas and parts of McCurtain and LeFlore Counties in Southeast Oklahoma. This summary was written after the analysis was completed and the text of the EIS was written. It provides only a glimpse of data contained in the two volume EIS.


1. APPALACHIAN MOUNTAINS
2. OZARK/OUACHITA MOUNTAINS
3. COASTAL PLAIN/PIEDMONT
SOUTHERN REGION
1
2
3
W. VIRGINIA
KENTUCKY
TENNESSEE
CAROLINA
SOUTH CAROLINA
OKLAHOMA
ARKANSAS
MISSISSIPPI
LOUISIANA
ALABAMA
GEORGIA
TEXAS
FLORIDA
DANIEL BOONE
JEFFERSON
CHEROKEE
OZARK
OUACHITA
CADDO NATIONAL GRASSLANDS
LBJ NATIONAL GRASSLANDS
DAVY CROCKETT
ANGELINA
SAM HOUSTON
KISATCHIE
HOLLY SPRINGS
TOMBIGBEE
DELTA
BIENVILLE
HOMOCHITTO
DESOTO
BANKHEAD
TALLADEGA
TUSKEGEE
CONECUH
CHATTAHOOCHEE
OCONEE
FRANCIS MARION
CROATAN
UWHARRIE
APALACHICOLA
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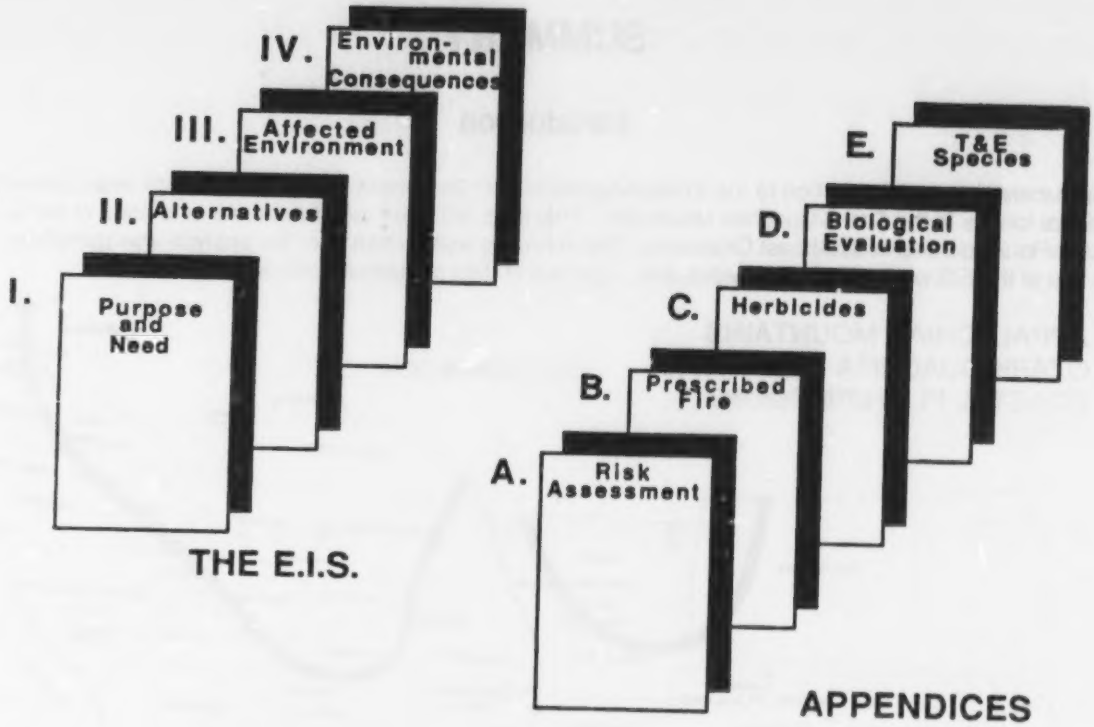
Vegetation management is the manipulation of plants by means other than timber harvest. It is done to help young trees survive and grow, to provide a variety of wildlife habitats, to reduce hazardous fuels, and to maintain safe and efficient travelways and utility lines.

The EIS discloses effects of vegetation management methods on human health and safety, wildlife, threatened and endangered species, vegetation, soils, water and aquatic animals, air, visual quality, cultural rersources, wildfire, recreation, and social and economic conditions. Based on issues raised by the public, the document evaluates eight alternatives that differ with respect to acres treated, mix of methods, and intensity of tools available in each method. **Alternative F is the preferred alternative.** This alternative decreases the use of herbicides, decreases use and intensity of mechanical methods, increases the use of manual methods, and increases prescribed fire though decreases its intensity. Prescribed fires are low to moderate intensity, and when herbicides are used priority is to use herbicides and application methods that pose minimum risks to humans, wildlife, and non-target plants.

Chapters I through IV form the heart of the EIS. Chapter I defines the need for vegetation management and displays issues. Chapter II explains each alternative, describes methods and tools, prescribes measures to mitigate environmental effects, and compares alternatives. Chapter III describes the environment of the Ozark/Ouachita Mountains. Chapter IV presents detailed analyses of environmental effects based on extensive scientific research. This summary presents highlights of these chapters.



The EIS also contains five major appendices. Appendix A is the Risk Assessment, a complex scientific document that analyzes herbicide risks to human and wildlife health. These risks are a product of the potency of each chemical and the degree of exposure to it. The evaluation compares herbicide doses people and animals may get with doses evaluated in laboratory studies. Each herbicide is analyzed for its potential to cause toxic and other effects such as cancer, mutations, and birth defects. Appendices B and C discuss the effects of prescribed fire and herbicides on soil and water. These appendices contain large bodies of research data under one cover and thus improve accessibility for readers. Appendix D is a biological evaluation of the effects of the preferred alternative on threatened, endangered, proposed and sensitive species. Appendix E lists proposed, threatened, endangered, and sensitive species.

Scope of Decisions

The Southern Region contains a variety of landscapes, plant communities, soil types, and climates. To account for some of these differences, the Region is divided into three areas to analyze vegetation management activities. This EIS covers the Ozark/Ouachita Mountains area. Other EIS's cover the Coastal Plain/Piedmont and Appalachian Mountains.

This EIS accepts the land allocation and resource output decisions of Forest Land and Resource Management Plans. It evaluates various vegetation management methods and tools needed to achieve Plan goals and objectives. The makeup of methods, tools, and mitigation measures in the selected alternative may require some changes in Plan direction.

The EIS discloses general effects over broad areas. Since environmental conditions can vary greatly from site to site, each project must be evaluated for its own site-specific effects. Site-specific analyses may reference (tier to) this EIS and EIS's accompanying Plans as appropriate. Methods and tools available for use on the ground are limited to those specified in the selected alternative.

Public Issues

About 300 people responded to a request to help identify five issues the EIS should address. These issues form the basis for developing and comparing alternatives. They express multiple concerns and values, many of which are opposed to each other.

Balance of Resources: At issue is the mix of resources and outputs produced. Some people believe that an increase in market outputs like timber conflicts with an increase in non-market outputs like aesthetics.

Prescribed Fire: This method is generally viewed as "natural" and needed for wildlife, some ecosystems, and wildfire control. Concern centers on season, frequency, and intensity of prescribed fires as they affect soil, water, air, and visual quality.

Manual Method: People like use of manual because they believe it provides employment and has less effect on non-targets than other methods. Some people recognize risks associated with manual methods but others suggest risks are less concern than unknowns with herbicides.

Herbicides: Many people fear that herbicides have serious effects on human health and on non-target plants and animals, or that they may have adverse effects on drinking water and aquatic communities. Some people fear that aerially or ground broadcast applied herbicides increase risk to human health and non-targets. Others vie aerial application as essential for economical treatment of some areas.

Mechanical Treatments: People suggest mechanical treatments should be used more in some areas. Possible adverse effects on soils, water, and aesthetics are of concern.

Affected Environment

This EIS covers 2.7 million acres on 3 national forests in Arkansas and Oklahoma. This area lies in two physiographic divisions: the Interior Highlands and two small units in the Coastal Plains. The Interior Highlands division includes the Ozark Plateaus and Ouachita provinces. The Ozark Plateaus province is a broad upland of sedimentary roads containing the Salem Plateau, Springfield Plateau and Boston Mountains. The Ouachita province is a series of parallel ridges and valleys formed by intense deformation of young sedimentary rocks. It contains the Arkansas Valley and Ouachita Mountains. The St. Francis National Forest lies on Crowley's Ridge in east Arkansas and the Tiak Ranger District is in the floodplain of the Little and Red Rivers in extreme southeast Oklahoma. Both of these units lie in the Coastal Plain physiographic province.

Major vegetation groups are the oak-hickory forests, dominant in the Ozark Plateau, oak-pine forests dominant in the Ouachita province and southern floodplain (bottomland) forests. There are 9 animal species and no plant species classified as threatened or endangered or proposed for listing. Soils are as varied as the geology and climate of the mountains, ranging from deep fertile soils in floodplains to soils severely eroded by past, inefficient farming, mining and logging. Water is usually abundant and of high quality. High yielding aquifers, however, are found principally in large river valleys and areas underlain by limestone.

Vegetation management is presently done on an average of 101,174 acres per year, or 3.7 percent of national forest lands in the Ozark/Ouachita Mountains. Of this total, 57,229 acres (56.5 percent) are now treated with prescribed fire; 7,868 acres (7.8 percent) with mechanical methods; 28,605 acres (28.3 percent) by herbicides; 7,472 acres (7.4 percent) with manual methods; and none by biological methods.

Vegetation Management Methods and Tools

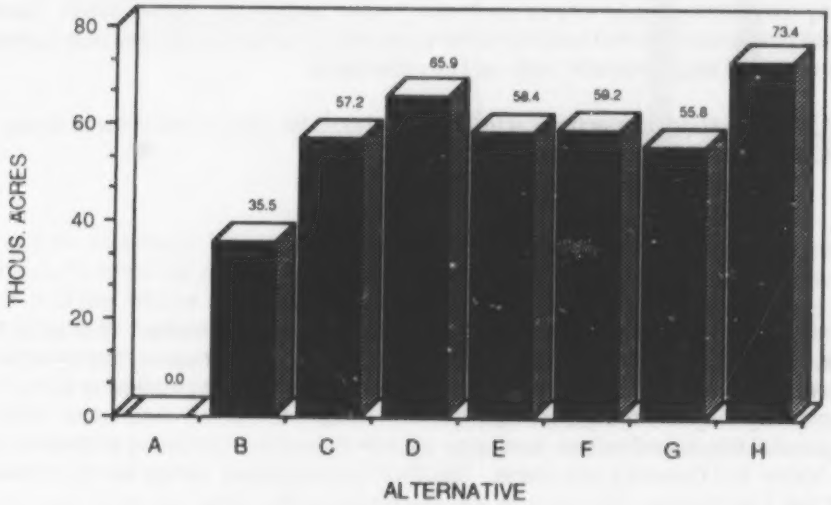
The five methods evaluated by the EIS are prescribed fire, mechanical, manual, biological, and herbicides. The mix of these methods varies markedly by alternative.

Prescribed Fire

Prescribed fire is the planned use of fire under specific conditions. Six firing techniques are used that vary how a fire is set in relation to the wind. Prescribed fires may be set by hand using drip torches or by using helicopters.

In general, light to moderate burns retain an effective ground cover of scorched or charred litter. Severe burns consume all litter and duff and alter the color and structure of mineral soil.

ANNUAL FIRE TREATMENTS



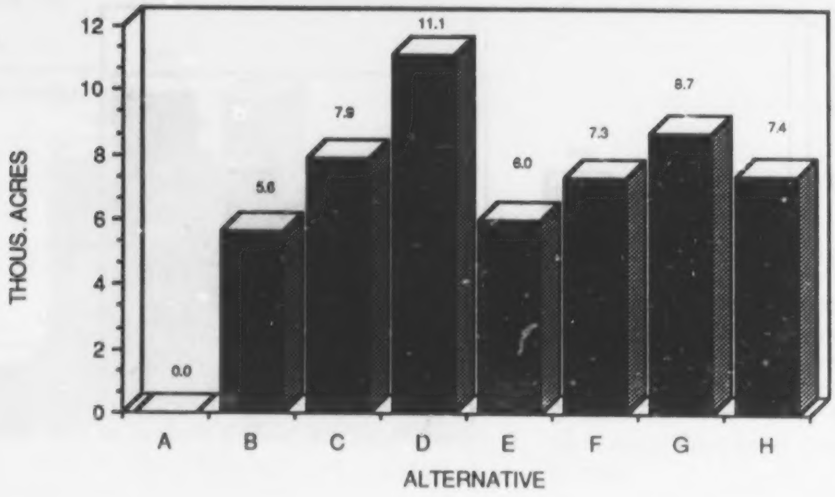
Mechanical Methods

Mechanical methods involve the use of ground machines. They are classed into three groups based on their potential for soil disturbance by erosion, compaction, and nutrient loss.

Mowing tools cut small vegetation above ground. Chopping tools are bladed drums that roll over and chop vegetation. Shearing tools are tractor-mounted blades that cut vegetation above ground. Scarifying tools scoop small depressions in the soil at wide intervals. Ripping tools plow furrows at wide intervals. Mowing, chopping, shearing, scarifying, and ripping cause low soil disturbance.

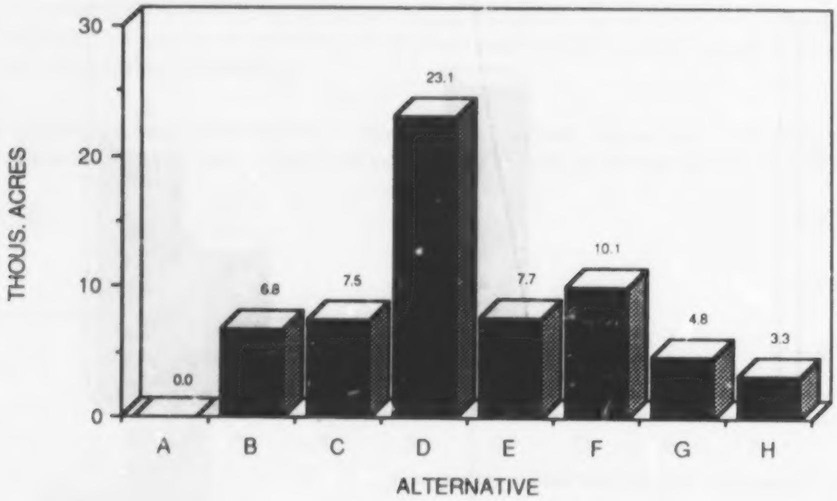
Piling causes moderate soil disturbance. Piling tools replace the dozer blade on tractors and roll vegetation, slash, and some litter into piles or windrows.

Raking and disking cause high soil disturbance. Unlike piling tools, raking tools push all litter and some topsoil into piles or windrows. Disking loosely tills soil.


ANNUAL MECHANICAL TREATMENTS

Manual Methods

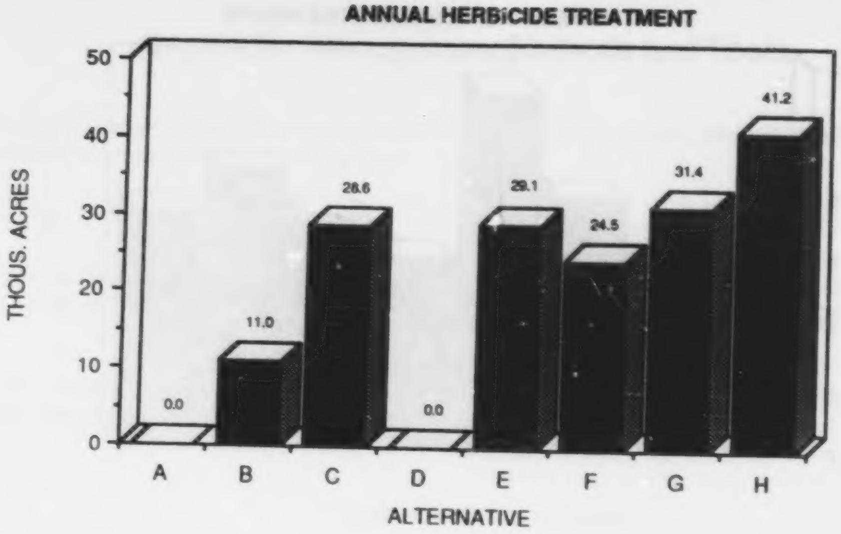
Manual methods employ hand tools to cut vegetation above ground. Non-power tools are axes, brush hooks, and clippers. Power tools include chain saws and brush cutters.


ANNUAL MANUAL TREATMENTS

Herbicides

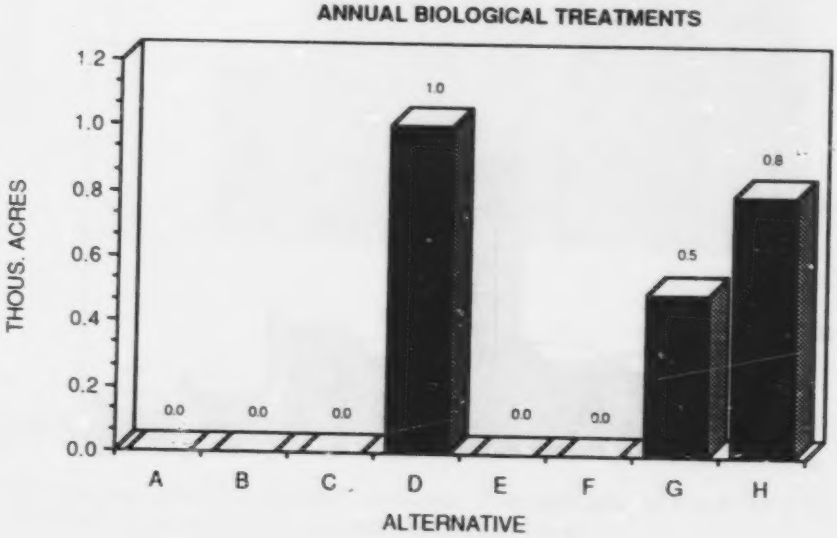
The 7 herbicides evaluated for use in the Ozark/Ouachita Mountains are fosamine; glyphosate; hexazinone; imazapyr; picloram; sulfometuron methyl; and triclopyr. In addition, four additives (diesel oil, kerosene, mineral oil, and limonene) were analyzed for their effects on human and wildlife health.

Herbicides are used to kill or suppress target plants. They are applied in liquid or granule form by hand, machine, or air. Hand applications use backpack sprayers and tree injectors for liquids and hand-held spreaders for granules. Machine and helicopter applications use boom/nozzle sprayers for liquids and power spreaders for granules.



Biological Methods

The only biological method evaluated is the use of livestock within existing grazing allotments.



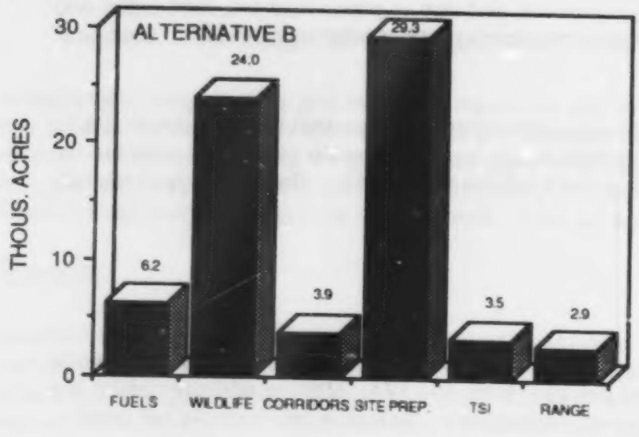
Alternatives

Eight alternatives were developed to respond to issues. They vary by acres treated per year, mix of methods, and intensity of tools used in each method.

Alternative A (No Action)

Vegetation management is not done. Existing vegetation is allowed to grow without manipulation.

Alternative B



Vegetation management is restricted to treatments which achieve minimum resource objectives. Nearly all activities receive treatments, but only when critically needed, and at low intensity. Acres treated per year total 58,815 and biological methods are not used. Use of herbicide methods is minor.

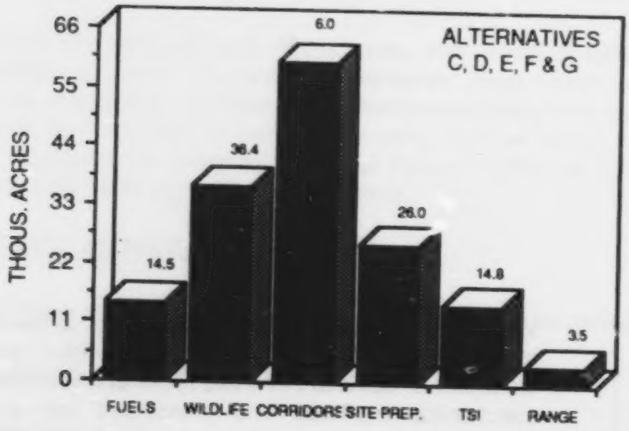
Herbicides are applied by hand. When they are used, priority is given to herbicides and application methods that pose minimum risks to humans, wildlife, and non-target plants. Mechanical treatments are limited to low-disturbance tools. Only low-intensity, less frequent prescribed fire is used.

Alternative C

This alternative continues present levels of treatment specified in Forest Land and Resource Management Plans. Acres treated per year total 101,174. Use of all methods except biological is fairly extensive, with prescribed fire and herbicides dominating.

Herbicides are applied by hand and machine. Mechanical methods cause low to moderate soil disturbance. Prescribed fire is low to high intensity. Grazing is not used. All sorts of manual treatments are done.

Alternative D



Herbicides are not used. Acres treated per year total 101,174. Acres treated with prescribed fire increase by 8,669, with mechanical increase by 3,273, with manual increase by 15,620, and with biological (pine release) increase by 1,043. These increases replace the use of herbicides. Mechanical methods cause low to moderate soil disturbance. Prescribed fire is low to moderate intensity. All sorts of manual treatments are done.

Alternative E

Use of mechanical methods decreases 1,872 acres from present, and use of prescribed fire, herbicides and manual methods increases to compensate for that reduction. Acres treated per year total 101,174. Biological methods are not used.

When herbicides are used, priority is given to herbicides and application methods that pose minimum risk to humans, wildlife, and non-target plants. Mechanical methods cause low to moderate soil disturbance but far less mechanical site preparation is done. Prescribed fire is low to moderate intensity. The full range of manual tools and treatments is available.

Alternative F (Preferred)

Use of manual methods and prescribed fire increases, and use of herbicides and mechanical methods decreases (a total shift of 4,636 acres). Acres treated per year total 101,174. Manual and prescribed fire treatments increase from present by 2,646 and 1,990 acres, respectively. Biological methods are not used.

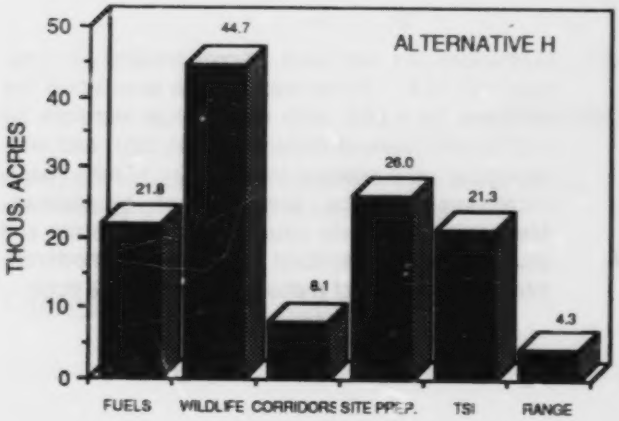
When herbicides are used, priority is given to herbicides and application methods that pose minimum risk to humans, wildlife, and non-targe plants. Mechanical methods cause low to moderate soil disturbance. Prescribed fire is low to moderate intensity. All sorts of manual treatments are done.

Alternative G

Use of herbicides increases by 2,783 acres from present levels. Use of mechanical methods also increase by 835 acres. Prescribed fire and manual methods use decreases comparably. Acres treated per year total 101,174. Emphasis is on herbicides and mechanical methods, and use of biological methods is minimal.

When herbicides are used, priority is given to herbicides and application methods that pose minimum risks to humans, wildlife, and non-target plants. Herbicides are applied aerially on 600 acres per year for site preparation and utility line maintenance. Mechanical methods cause low to moderate soil disturbance. Prescribed fire is low to moderate intensity.

Alternative H



Vegetation management is done to achieve maximum vegetation control. Herbicides are broadcast at maximum effective rates, and intensive mechanical methods and prescribed fire are favored. Acres treated per year total 126,156. Emphasis on herbicides and prescribed fire increases markedly from present.

Herbicides are applied by hand, machine, and air. Herbicides are applied aerially on 14,500 acres per year fo pine release, utility line maintenance, and site preparation. Mechanical methods cause low to high soil disturbance. Prescribed fire is low to high intensity.

Management Requirements and Mitigation Measures

Management requirements and mitigation measures are "do's" and "don't's" applied on the ground to assure that treatments accomplish their objectives and produce fewer adverse impacts and more benefits. Some requirements and measures are general and apply to all vegetation management methods. Others pertain to only one method. Analysis shows they significantly reduce adverse environmental effects. Chapter II covers them in detail and discusses their effectiveness. They are summarized below.

General

Detailed site-specific analyses and biological evaluations are required for each project. Timber stand improvement guides ensure adequate tree stocking and growth. Stream stability is protected by retaining bank vegetation and preventing debris deposits. Cultural resources are inventoried and protected. Safety equipment is mandated for field workers. Methods and tools are matched to visual quality objectives, and treatments are timed to protect scenic values. Vegetation is treated to enhance variety of wildlife habitat. Corridors are managed to control erosion, protect public safety and facilities, and enhance wildlife, recreational and visual values. Native plants, unique features, and public use of recreation areas are protected.

Prescribed Fire

Timing and intensity of burns are controlled to protect crop and wildlife trees and nesting animals, limit soil damage, and reduce erosion, sediment loads, and smoke emissions. Firelines are built and maintained to reduce erosion and sediment and protect wetlands. Burns are patterned to enhance variety of wildlife habitat.

Mechanical Methods

Erosion and sediment are reduced by mandating slope limitations, contour tillage, buffers along streams ,and prompt revegetation. Treatments are timed to limit soil compaction. Roads, trails, and ditches are kept free of debris.

Herbicides

Choice of herbicide and method, rate, and timing of application are managed to reduce risks to humans, wildlife, and other environmental elements. Supervision and training of applicators are mandatory to reduce risks of accidents and exposure. Protective clothing and safety equipment are mandated to reduce exposure. Drift of herbicides is reduced by using special spray nozzles and applying during favorable weather. Precautions are specified to reduce risks of spills and water or worker contamination. Water supplies and adjacent lands are protected by buffers.

Biological Method

Stocking and grazing patterns are controlled to reduce damage to soil, water, and the forage resource.

Manual Method

Safety is provided through training and use of protective equipment.

Environmental Consequences

Chapter IV presents detailed analyses of effects of vegetation management methods on various environmental elements. It also summarizes effects of alternatives on each element. Alternatives differ with respect to acres treated, mix of methods, and intensity of tools available in each method. Each of these factors influences the direction and severity of environmental effects. This section of the summary briefly discusses effects on key environmental elements.

Alternative A treats no acres. Alternative B treats minimum numbers of acres for basic resource protection. Alternatives C, E, F, and G employ all methods and use low- to moderate-disturbance tools. Alternative D eliminates the use of herbicides. Alternatives C and H use high-disturbance tools such as severe slash burns. Raking, and heavy disking are also used in alternative H which treats the most acres and increases the use of high-disturbance tools.

Human Health and Safety

All herbicides and additives investigated provide ample margins of safety for the public when applied using typical rates and methods. However, because 2,4-D; 2,4-DP, picloram, dicamba, and tebuthiuron have lower margins of safety or pose possible environmental risks they were not considered for use in the Ozark/Ouachita Mountains area. In general, worker exposure is reduced by aerial application.

Accidental injuries from other methods pose greater risks to workers than health impacts from herbicides. Accidents are most common and severe with manual methods. Prescribed fire poses the next highest risk. Alternative A poses the lowest overall risk to human health and safety because no tools are used and risks are limited to wildfires.

Wildlife

All 11 herbicides and 4 additives provide ample margins of safety for terrestrial and aquatic wildlife when applied using typical rates and methods. When applied at extreme rates, six chemicals pose risks to some species. Only three of these, hexazinone, triclopyr and limonene are prepared for use. Accidental spills of some chemicals into surface water would pose risks to some aquatic species.

Vegetation management benefits some wildlife species and harms others. For example, lack of treatment or low-disturbance tools favor mid- to late-successional habitats and associated wildlife; whereas early successional habitats and wildlife are favored by more intensive treatments. Alternatives C, E, F, and G provide the greatest variety of habitats and associated wildlife, because they have the most balanced mix of low- to moderate-disturbance tools.

Threatened and Endangered Species

Some species occur only in habitats where no vegetation management occurs. Low toxicities to animals, low risk of exposure and use of biological evaluations limit risks of adverse herbicide effects on listed animals. Since threatened or endangered plants may be extremely sensitive to herbicides, mitigation measures and biological evaluations are essential for protecting these plants.

Lack of treatments may prevent recovery of species which require periodic disturbance. Many species are fire-dependent, and some are sensitive to intensive or frequent treatments.

Vegetation

Lack of treatment or use of low-disturbance tools favors woody species. High disturbance favors herbaceous species. Alternative A most favors woody understory and midstory species.

Soil

Severe slash burns and raking pose high to extreme risks to soil productivity on all soils, mainly through loss of organic matter and nutrients. Moderate slash burns and piling pose low risks on some soils. Soil compaction is only significant for raking on clay and loam soils. Erosion is most severe after heavy disking. Raking and disking though occur only in alternative H.

Lack of underburns in alternatives A increases occurrence and adverse effects of wildfires. Alternatives B, E, and F best protect soil productivity because only low- to moderate-disturbance tools are used and underburns reduce wildfire effects.

Water

No method significantly affects chemical water quality. Because herbicides are applied at low rates, are separated from streams and wells by buffers, and are subject to considerable downstream mixing and dilution, risks to water from typical application are very slight. Aerial herbicide application, however, increases risks of accidental pollution of streams.

In general, stormflows and sediment loads are increased slightly by low to-moderate disturbance tools, and substantially by high-disturbance tools like severe slash burns, raking and heavy disking. Lack of underburns in alternative A slightly increases occurrence of severe wildfires. Alternative A best protects water quality, but B and F do almost as well.

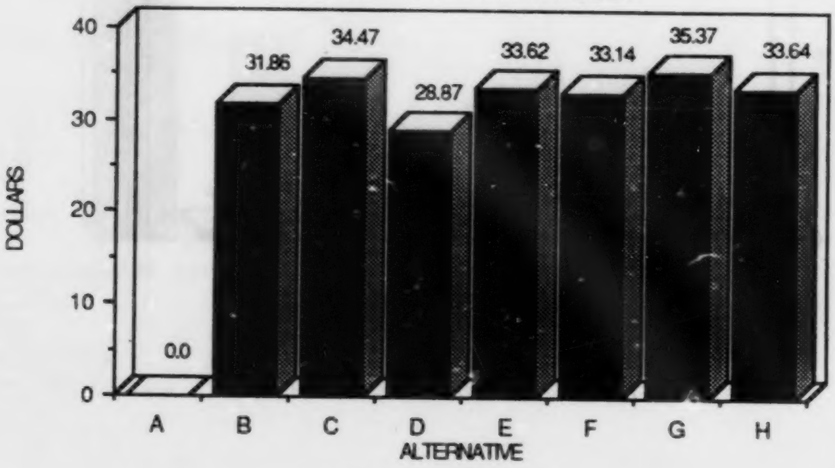
Air

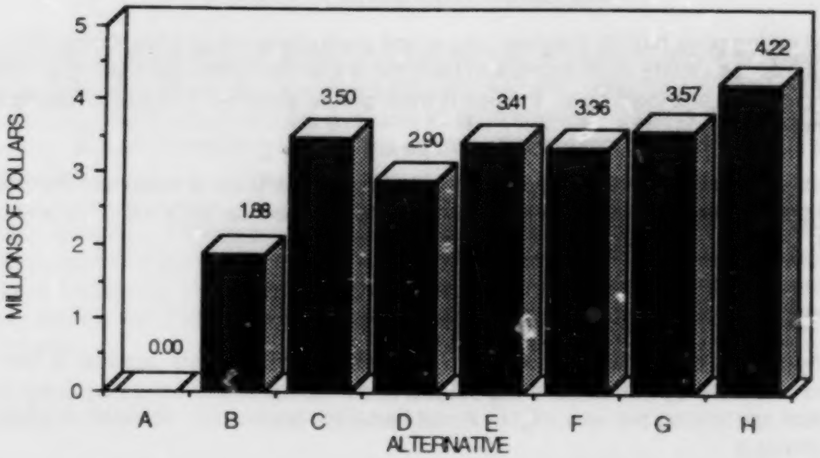
Emissions of pollutant gases (carbon monoxide, hydrocarbons, nitrogen oxides, sulfur oxides, photochemical oxidants) are generally not sufficient to pose significant risks to air quality. Particulate emissions are least for grass and pine-grass underburns, moderate for slash burns and pine-light brush underburns, and highest for wildfires. Long-term exclusion of underburns can cause available fuels to triple in some forest types, thus greatly increasing potential for wildfire incidence.

Economics

Direct, per acre costs are lowest for prescribed fire. Opportunity costs (sacrificed outputs) are generally reduced as market outputs increase. Lack of treatment reduces outputs and induces damages to facilities such as roads and other capital investments which deteriorate from lack of maintenance. Alternatives F and H have the greatest advantage because their direct costs are among the lowest and their indirect costs are low to moderate.

PER ACRE TREATMENT COST





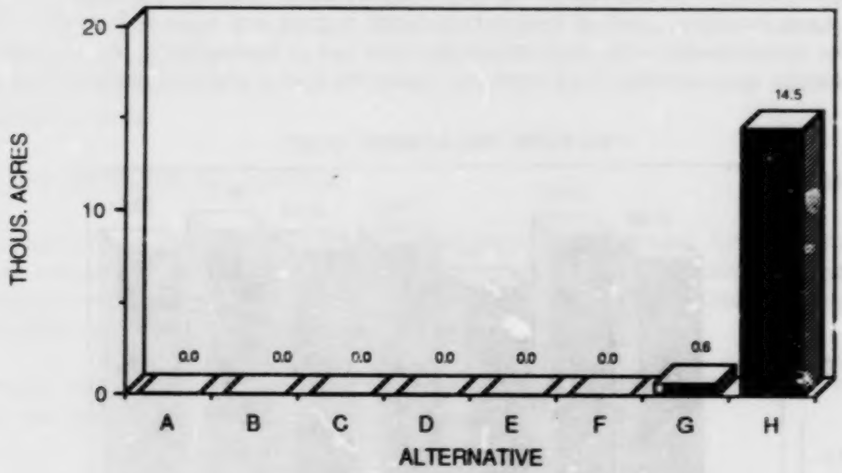
TOTAL ANNUAL COST

Social Values

Public response becomes negative at the extremes of no treatment or high-disturbance tools, and positive with manual methods. Visual values decline with high-disturbance tools, but vistas are lost if treatments are excluded. Cultural resources are most damaged by soil tilling tools like disking and raking. Alternatives E and F have the greatest advantage because public acceptance becomes positive and risks to visual values and cultural resources are moderate.

Aerial Application

Two alternatives, G and H, include the use of aerial application of herbicides by helicopter. Alternative G treats 600 acres (about .02 percent of the study area), and alternative H treats 14,500 acres (about .50 percent of the study area).



HERBICIDE ANNUALLY APPLIED AERIALLY

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CHAPTER I

Purpose and Need

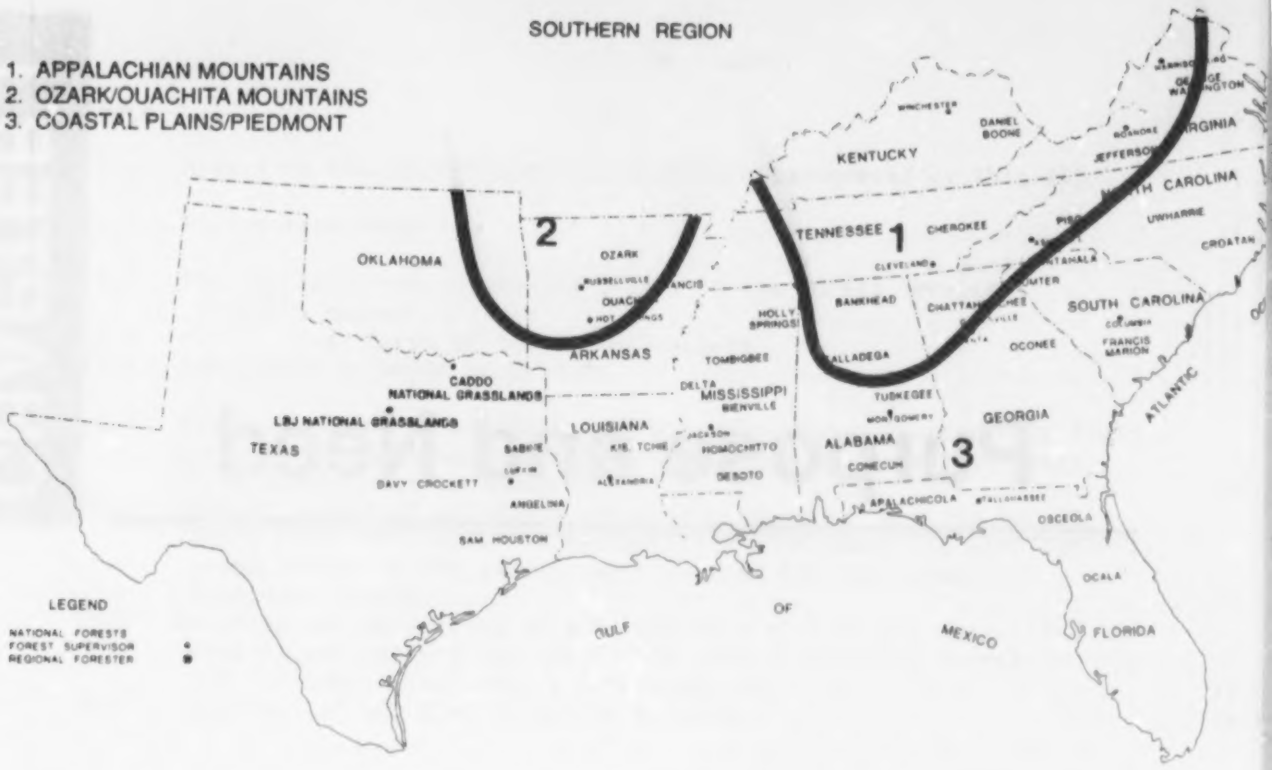

SOUTHERN REGION
1. APPALACHIAN MOUNTAINS
2. OZARK/OUACHITA MOUNTAINS
3. COASTAL PLAINS/PIEDMONT
1
2
3
OKLAHOMA
OZARK
RUSSELLVILLE
OUACHITA
HOT SPRINGS
ARKANSAS
CADDO NATIONAL GRASSLANDS
LBJ NATIONAL GRASSLANDS
TEXAS
SABINE
LUFKIN
DAVY CROCKETT
ANGELINA
SAM HOUSTON
LOUISIANA
KIS. TCHIE
ALEXANDRIA
MISSISSIPPI
HOLLY SPRINGS
TOMBIGBEE
DELTA
BIENVILLE
JACKSON
HOMOCHITTO
DESOTO
KENTUCKY
WINCHESTER
DANIEL BOONE
TENNESSEE
CHEROKEE
CLEVELAND
ALABAMA
BANKHEAD
TALLADEGA
TUSKEGEE
MONTGOMERY
CONECUH
GEORGIA
CHATTAHOOCHEE
OCONEE
SOUTH CAROLINA
COLUMBIA
FRANCIS MARION
SUMTER
NORTH CAROLINA
PISGAH
NANTAHALA
UWHARRIE
CROATAN
VIRGINIA
JEFFERSON
ROANOKE
GEORGE WASHINGTON
APALACHICOLA
TALLAHASSEE
OSCEOLA
OCALA
FLORIDA
ATLANTIC
GULF
OF
MEXICO
LEGEND
NATIONAL FORESTS
FOREST SUPERVISOR •
REGIONAL FORESTER ●

Figure I-1.--Area 2 is the Ozark-Ouachita Mountains Area covered by this EIS.

Organization of this Document

This EIS follows the format recommended by the Council on Environmental Quality. Chapter I, Purpose and Need tells who, what, where, and why about the environmental analysis, and states the issues. Chapter II, Alternatives describes how alternatives were developed, explains which ones are considered, summarizes environmental effects, and identifies the preferred alternative. Chapter III, Affected Environment describes parts of the environment that would affect or be affected by the alternatives. This chapter does not describe effects (see chapter IV). Chapter IV, Environmental Consequences describes environmental impacts of alternatives, including the proposed action. Chapter V is a list of preparers and their experience and qualifications. Chapter VI shows consultations which were made and who received copies of the EIS. Chapter VII is a glossary of terms and acronyms. Chapter VIII lists reference materials. Chapter IX contains an index. Appendices contain specific information on topics too lengthy, technical, or detailed to be included in the text. Readers can quickly grasp important aspects of this EIS by reading the Summary beginning on page i in the preceding section.

Part of the EIS analysis includes a risk assessment, presented in appendix A. A summary of the risk assessment is available from USDA Forest Service, Southern Region, 1720 Peachtree Road, N.W., Atlanta, Georgia 30367.

CHAPTER I

PURPOSE AND NEED

IN BRIEF

Part A tells who prepared this environmental impact statement and what it is about. Part B tells why vegetation management is done. Parts C and D tell what decisions this document supports, how they relate to Forest Land and Resource Management Plans, and how they are implemented. Part E is an overview of the public involvement process. Part F contains a complete description of issues addressed. Part G describes some of the social aspects of herbicide use and briefly tells how and why the risk assessment was prepared.

A. INTRODUCTION

National Forests of the Southern Region are managed to provide a mix of goods and services to the public. Each Forest Land and Resource Management Plan details specific resource management objectives and output goals. These plans provide for access to the national forests, livestock grazing, timber management, visual quality, water quality, and vegetation, wildlife and fish diversity. To produce these outputs some vegetation management must be done. Different environmental conditions, objectives and goals determine the need for and amount of vegetation management done.

1. Area Analyzed

This environmental impact statement (EIS) prepared by the USDA Forest Service Southern Region discloses environmental effects of vegetation management on national forests of the Ozark/Ouachita Mountains (figure I-1). For administrative reasons, the St. Francis National Forest and the Tiak Ranger District of the Ouachita National Forest, both in the Coastal Plain, are also covered. This EIS was guided by the National Environmental Policy Act of 1969 as amended, Council on Environmental Quality Regulations, and USDA Forest Service implementing procedures (FSM 1950).

2. Activities Addressed

The vegetation management program covered by this EIS contains six activities. These activities are:

- Site preparation for reforestation of pines and hardwoods; which is done to reduce plant competition so that pine and hardwood seedlings and saplings get needed amounts of sunlight, water, nutrients, and growing space in order to survive and grow in newly established stands.

- Stand management for timber stand improvement (release, precommercial thinning); which maintains balanced species composition and vigorous growth conditions for trees by controlling plant competition.

- Wildlife habitat improvement, including openings maintenance; which provides a wide variety of plants and habitat conditions beneficial to wildlife, and also protects and enhances habitats of threatened, endangered, proposed, and sensitive plant and animal species.

- Corridor maintenance for roads and trails, utilities, and railroads; which provides safe travelways and protects investments.

- Range forage improvement; which maintains plant species used by livestock.

- Fuels treatment; which is done to reduce hazardous fuels and risks of wildfire damage.

Activities affecting vegetation not addressed include silvicultural systems, harvest cutting methods, road construction, recreation and administrative site maintenance, and management of nurseries, seed orchards, and aquatic vegetation.

3. Methods Evaluated

The EIS examines environmental effects of five vegetation management methods. These methods are:

- Herbicides, which can be applied as granules or liquid droplets by hand, machine, or helicopter.

- Mechanical, the use of machines such as mowers or tractors and bulldozers with attachments.

- Prescribed fire, which can be applied by ground and aerial ignition tools.

- Manual, the use of hand-held tools.

- Biological, the use of livestock to control vegetation by grazing.

B. NEED FOR ACTION

Vegetation management is the manipulation of plants to benefit a variety of forest resources and investments. It is needed to protect and improve forest health, wildlife habitat, and range forage. It is required to maintain facilities such as roads, trails, and utility lines. It is essential to meet the special needs of some threatened, endangered, proposed, and sensitive species. Forest Land and Resource Management Plans call for many vegetation management activities. This EIS discloses environmental effects of those activities.

1. Strategies for Vegetation Management

Vegetation management is the control of plant growth. Growth of some plants is undesirable if they compete vigorously with desired plants for sunlight, water, nutrients, and growing space. Growth of other plants may pose a fire hazard in some forest sites or a safety hazard in corridors and recreation sites.

All vegetation is part of an ecological system. A plant species may be desired on most sites but not others. For example, thick grass and low shrub growth may be wanted in a utility corridor but may crowd out young trees in a forest stand. Snags create wildlife perching and nesting sites in the general forest but pose a safety hazard along roads and trails. The need for vegetation management depends on objectives for each site.

On national forests, just enough treatment is usually done to meet minimum vegetation management needs. For example, pine stands are managed to include a hardwood component of up to 30 percent. Utility lines and roadsides may be managed for a variety of low-growing plants. Four strategies are available to meet the vegetation management needs of any given site:

Prevention, treating before damage occurs. Prevention activities usually intervene once in natural plant growth and succession to give desirable plants a temporary growth advantage over undesirable ones. Examples are site preparation and timber stand improvement.

Maintenance, treating in planned cycles. Maintenance activities intervene frequently in natural plant growth and succession to perpetuate a given state. Examples are fuels treatment, wildlife habitat and range forage improvement, and maintenance of corridors.

Correction, treating after damage occurs. Correction activities may be needed if prevention or maintenance was not done or not effective. Examples are restoring overgrown wildlife openings or failed regeneration areas.

No action, no treatment. Natural processes are allowed to progress without human intervention. No action is an option in most activities. For example, some sites do not require site preparation or timber stand improvement to achieve adequate stocking of desired tree species.

2. Treatments and Their Effectiveness

Effectiveness is measured by how well one treatment achieves the desired plant control results. It varies with choice of method and tool and type and timing of treatment.

Effectiveness of competition control with manual and light mechanical methods (mowing, chopping, shearing, ripping, scarifying) is typically low because regrowth of herbaceous plants and resprouting of woody plants is usually immediate and vigorous. Raking and disking are more effective in reducing competing woody plants since they affect their root systems, but they also may severely impact resources such as soil and water.

Effectiveness of prescribed fire and biological methods varies with intensity of burning or grazing. Herbicides are highly flexible because choice of herbicide and method, rate, and timing of treatment can be varied to affect different plants in different ways.

Broadcast treatments cover an entire area and affect many plants. Selective treatments affect only a few individual plants in an area. Manual treatments are mostly selective. Prescribed fire, mechanical, and biological methods are mostly broadcast treatments. Herbicides may be applied by selective or broadcast means.

Timing of treatment can modify a tool's effectiveness. For example, an intense dormant season fire eliminates few woody plants from a site if they are vigorous sprouters. However, a light to moderate growing season burn may eliminate many of the same plants by occurring after they have used up the season's root reserves and so cannot resprout as vigorously.

3. Objectives and Treatments for Vegetation Management

This EIS covers the six vegetation management activities listed on pages I-1 and I-2. Each activity has a unique set of objectives; together with site conditions, these objectives determine the type and degree of plant control desired and the strategy and treatments that are most appropriate.

Fuels Treatment

Fuels are reduced in some yellow pine and pine-hardwood stands to keep them from building up to hazardous levels. Fuels are treated about once every 6 years in the Ozark/Ouachita Mountains. Prescribed fire is the only effective method, since it consumes fuels while other methods merely redistribute them.

Wildlife Habitat Improvement

This activity includes maintenance of wildlife openings, as well as understory treatments in the general forest to enhance habitat variety and protect habitats of threatened, endangered, proposed, and sensitive species.

Wildlife openings are maintained to perpetuate open areas rich in herbaceous and shrubby food plants. Mowing may be done more than once a year. Herbicides, prescribed fire, and manual methods may also be used to reduce or kill encroaching shrubs and vines. Many openings are periodically disked and replanted to rejuvenate their cover.

Understory treatments may be done every 3 to 5 years to open up the understory and spur the growth of woody and herbaceous food plants. Prescribed fire is an excellent broadcast method for producing these results. Manual and selective herbicide treatments are used to remove individual midstory trees; herbicides generally eliminate the resprouting that commonly follows use of manual methods.

Range Forage Improvement

This activity is similar to wildlife habitat improvement. It includes maintenance of open pastures, as well as understory treatments in the general forest to enhance growth of herbaceous food plants used by livestock.

Understory treatments are usually done every 5 years to open up the understory and improve palatability of food plants. Prescribed fire is used most to achieve these results, but herbicides and manual methods may also be used to remove selected midstory and understory trees as well as thickets of brush. Treatments in open pastures are often done more frequently.

Corridor Maintenance

This activity includes maintenance of trails, roadsides, and utility (mostly power and gas) lines. Prescribed fire is almost never used due to risks to resources, investments, and forest visitors.

Trailside vegetation is treated each year to keep the trail open and maintain vistas. Nearly all work is done by manual methods. Herbicides are used to control some noxious or fast-growing plants. Some grassy trail heads and overlooks are mowed.

Roadsides are treated to maintain low-growing plants for safe sight distances and faster drying by sunlight. Mowing is used most, but herbicides are also used to reduce prolific woody growth and favor grasses and flowering plants. Manual methods are often used at sensitive sites such as stream crossings. A segment of Forest Service road is usually treated once every 3 years, but county/State roads may be treated annually.

Utility lines are treated to maintain low-growing plants that will not interfere with operation. Treatments occur about every 6 years in power lines for a low brush and herbaceous cover and every 2 years in gas lines for a continuous herbaceous cover. Mowing is favored on gentle terrain and herbicides are favored elsewhere. Manual methods are used least since they often promote vigorous resprouting of woody plants.

Site Preparation

Site preparation is done near the start of each rotation to give desired seedlings enough light, water, nutrients, and space to become firmly established. It is done to enhance natural or artificial regeneration in evenage or unevenage management. It usually follows clearcut or seedtree harvest but often precedes shelterwood or selection harvest.

Herbicides and prescribed fire are used most for pine site preparation. Herbicides are very effective in providing precise competition control. Manual or mechanical methods followed by prescribed fire can retard hardwood sprouting if timed to help exhaust root reserves. Herbicides followed by prescribed fire ("brown and burn") are sometimes used to control intense competition on productive sites. Manual methods alone may be ineffective due to resprouting, and mechanical methods are restricted to gentle terrain.

Manual methods and pre-harvest herbicide treatments are used almost exclusively for hardwood site preparation. Prescribed fire is rarely used, and mechanical methods are never used. Manual methods are used most, but selective herbicide treatments can reduce understory competition before harvest to give some desirable species a better chance to become established.

Timber Stand Improvement

This activity includes release, precommercial thinning, and understory species control. Release occurs in a stand's first few years, precommercial thinning after the first few years, and understory species control usually after crown closure. Their objective is to give desirable trees a growth advantage over competing trees.

Nearly all timber stand improvement occurs as release. Only herbicides and manual methods are used; herbicides are much more effective in controlling resprouting. Precommercial thinning is done with manual tools, although some can be done with mechanical tools. Understory species control is done mostly with prescribed fire to top-kill competing trees; use of manual and selective herbicide treatments to remove individual midstory trees is limited.

4. Harvest Systems and Vegetation Management

Timber harvest systems and vegetation management must conform to the biological needs of the desired tree species. Tree species are grouped into 3 classes based on their ability to reproduce and grow despite shading and root competition from other species:

Intolerant species require much light and do not tolerate strong root competition as young trees. They have high rates of photosynthesis, respiration, and growth. They include the pines and such hardwoods as black cherry, walnut, and a few oaks.

Intermediate species require moderate light and/or good competition control as young trees. They therefore need careful treatment to successfully regenerate and develop into quality timber. They include many of the oaks and hickories.

Tolerant species do well in (and may require) little light and tolerate root competition as young trees, and usually respond well to release. They have relatively low rates of photosynthesis, respiration, and growth. They include beech, most maples, and some elms.

Evenage systems include clearcut, seedtree, and shelterwood harvests. Unevenage systems include single-tree and group selection harvests. Clearcut and seedtree harvests create open conditions with abundant light. Shelterwood and group selection harvest can be varied to create low to abundant light. Single-tree selection harvests usually create low to moderate light.

Intolerant species are regenerated by harvest systems that create open conditions with abundant light. However, these conditions also favor pioneer species such as dogwood, black locust, and red maple which reproduce and grow profusely. Even after effective site preparation, release is usually needed to prevent these species from overtopping and killing desired trees. Herbicides are often used to prevent pioneer species from resprouting and overtaking the desired trees.

Intermediate species are regenerated by harvest systems that create moderate to abundant light. Care is needed to create and maintain just the right amount of light and space to give these slower-growing species an edge over more tolerant and intolerant trees. Pre-harvest site preparation with fire and selective herbicide treatments is often used to prepare the seedbed and aid early growth. Post-harvest release with selective herbicide treatments is often used to control the amount of light and space around desired trees and keep them from being crowded out or overtopped.

Tolerant trees can be regenerated by almost any harvest system. They will be overtopped by pioneer species in open stands with much light, but will outlive these trees and eventually take their place in the overstory. They will survive for years under closed stands with little light and will usually respond well to release.

C. SCOPE OF DECISIONS

This EIS is used to make decisions about how the vegetation management program on national forests in the Ozark/Ouachita Mountains is conducted. Major decisions are: (1) what methods and tools are allowed; (2) what intensity and frequency of treatments are used; and (3) what management requirements and mitigation measures are applied. The EIS provides analytical data that may be used when making site-specific decisions in the future.

D. IMPLEMENTING THE DECISION

Decisions based on this EIS are implemented in concert with Forest Land and Resource Management Plans. Plans set overall direction for managing national forests. The selected alternative from this EIS sets further direction on how vegetation is managed. Depending on which alternative is selected, Plans may need to be amended, especially regarding methods and tools allowed and mitigation measures (standards and guides) applied. Amendments to Plans will be done through the Record of Decision which follows this EIS.

Site-specific vegetation management projects must be done within constraints set by the Plans and this EIS. Together, these two documents define the limits within which such projects may operate. Key components of project implementation include site analysis, project design, and monitoring.

1. Site Analysis

Vegetation management projects must receive site-specific environmental analysis in compliance with the National Environmental Policy Act (NEPA). Data on sites eligible for treatment are gathered and evaluated by trained personnel familiar with local environmental conditions and relationships. A detailed analysis of site conditions and environmental effects of alternative treatments is done. Information from this EIS and those done for Plans is used when applicable and valid. NEPA procedures ensure that information is available to public officals and citizens before decisions are made or actions are taken.

The analysis must evaluate direct, indirect, and cumulative environmental effects of vegetation management, considering the unique physical and biological characteristics of the site. It must evaluate a reasonable range of alternatives, including a "no action" alternative, which vary the mix of methods and intensity of tools used within the constraints set by this EIS and the Plans.

Effects to be evaluated include long-term soil productivity; water, air, and visual quality; vegetation; wildlife; fish; cultural resources; and effectiveness of treatments. A biological evaluation of potential effects on threatened, endangered, proposed, and sensitive species is also done.

2. **Project Design**

Good design requires a thorough analysis. Project design depends on the effectiveness of treatments in meeting project objectives and on environmental effects they cause. Equally important are the constraints set by the alternative selected in the Record of Decision which follows this EIS. This alternative defines methods and tools that are allowed, intensity and frequency of treatments that must be used, and minimum mitigation measures that must be applied. Managers must work within these constraints to decide which vegetation management methods are best suited to the specific site conditions. Projects that are structured and timed to meet vegetation management objectives well and to pose minimal environmental risks are usually favored.

3. **Monitoring**

Monitoring of environmental effects is done during and after treatment to assure that the project is implemented as designed and that mitigation measures are effective. Information gathered may be used to validate or refine treatments or to add further mitigation measures. A full array of treatments in diverse environmental conditions is monitored. Minor projects and those whose effects are already well documented may not be monitored.

Effects of treatments on vegetation, soil, wildlife, and threatened or endangered species are monitored in the treated area. Effects on water and aquatic life may be monitored onsite and downstream. Effects on air quality may be monitored onsite and downwind.

Monitoring during treatment is important if changes in tools or intensity are needed. Most monitoring is done just after treatment and at appropriate intervals thereafter. Monitoring is seldom needed beyond 3 years after project completion.

E. PUBLIC INVOLVEMENT

A public involvement summary is in chapter VI. The Notice of Intent to prepare this EIS was published in the September 11, 1986 Federal Register. A revised Notice of Intent, based on early scoping results, was published in the May 5, 1987 Federal Register. This revision described methods which would be evaluated and estimated dates of availability of draft and final statements.

In June 1988 more than 5,000 interested individuals, groups, and agencies were asked to identify issues to be addressed in this EIS. Concurrently, a press release was distributed Regionwide. Some key contacts were also reached by phone or in person. Between June and August 1988, replies were received from 270 respondents. Analysis of this public response identified 5 issues to be addressed. In November 1988, 5,000 information tabloids about issues and alternatives were distributed.

F. ISSUES ADDRESSED

An issue is a subject or question of widespread public interest relating to management of a national forest. The following issues incorporate concerns expressed by the public, employees, and managers in the 270 responses we received in 1988.

1. Prescribed Fire

Most people think prescribed fire is an effective vegetation management tool that benefits wildlife habitat and plant diversity. Prescribed fire is also viewed as a viable (perhaps the only) method for wildfire prevention by burning excess fuel. But there are concerns about possible adverse effects on soil productivity, public health and safety, and water, air and visual quality. Size, frequency, distribution and season of prescribed fires must be carefully planned and controlled to protect these values and assure that burning objectives are met.

2. Herbicide Use

Most people are concerned about herbicide use more than any other vegetation management method. Potential harmful effects on wildlife, threatened and endangered plants and animals, non-target plants, diversity of plant and animal species, fish, water quality and soil productivity are major concerns. People want a risk assessment done for human health and safety. They also want more information about long-term herbicide effects and what constraints should be applied to herbicide use.

If herbicides are used, people want well trained, informed, supervised applicators who respect their potential dangers. Some think aerial application costs less, but most generally favor hand treatments and are concerned about potential drift to non-targets. They are also concerned about possible ground and surface water pollution from aerial or other broadcast treatments. A few people recommend aerial application as the most economical and proper means to maintain utility lines.

3. **Mechanical Methods** Concerns about use of mechanical methods are not as intense as those for herbicides or prescribed fire. They are strongest about potential soil erosion, stream siltation and soil compaction. Many people stated that, since mechanical tools are not target-specific, plant diversity might be lost. But some felt that mechanical tools can produce an aesthetically pleasing effect. There was some concern that mechanical methods can be more expensive than others. Overall, there seems to be a lack of understanding about what constraints now exist for use of mechanical methods.

4. **Manual Methods** People believe manual methods have more favorable effects on local employment, plant and animal diversity, worker health and safety and cost than others. Employment and income are low in most rural areas and this method is seen as offering needed employment. Manual tools are more selective and less site-disturbing but pose higher health and safety risks. People prefer manual methods over herbicides due to perceived chemical risks to the environment and long-term human health. This method can be more costly than others but is favored for its possible increased economic benefits to the area.

5. **Balance of Resources** Many people think vegetation management should not be used to increase pine production at the expense of diversity. Some respondents proposed grazing as a biological control but are concerned about domestic animals infecting wildlife with parasites and diseases. Most people agree that managers need flexibility to determine proper methods, but they want non-timber values considered. They also want information on what values are being considered, the effects of various methods, and how the agency would implement treatments.

There is considerable support for managing vegetation to improve wildlife habitat, but there is concern about adverse effects on aesthetics (especially in high-use areas), water quality and soil productivity. Many responses favored vegetation management for specific reasons but were unsure of overall effects.

These issues were used in formulating and evaluating alternatives (chapter II). The effects of the alternatives on issues are identified and these effects are considered when choosing the preferred alternative.

6. Unrelated Comments

Several comments were received on a wide range of topics beyond the scope of this EIS. These comments, though meaningful, are not included as issues. Some categories of comments which won't be addressed are silvicultural systems, harvest cutting methods, off-road vehicles, littering, road construction, wilderness designation, military uses, minerals, forest signs, landscape-wide diversity, illegal activities, southern pine beetle, beavers, or multiple-use in a general landscape-wide sense.

Most of these unrelated comments have been analyzed and addressed in Forest Land and Resource Management Plans. For example, each Plan discusses which silvicultural system and associated harvest cutting methods are appropriate, and where they are to be used, based on each forest's unique mixture of resources and public needs. This EIS does not reanalyze those issues, but does evaluate vegetation management methods for the activities listed in section A of this chapter.

G. ABOUT HERBICIDES

This EIS discloses the analysis of five methods of vegetation management, but herbicide use is a focal point of controversy. Issues about herbicides are both scientific and emotional. The public seems to distrust forest managers who use herbicides. The respondents to our inquiry expressed fear of adverse health effects, including cancer. And, indeed, there is some scientific uncertainty about long-term effects of many herbicides. People commonly ask questions like, "Do these herbicides cause cancer or birth defects?" "What are the short-term and long-term effects of exposure to herbicides?" and "How do they affect wildlife and other aspects of the environment?"

CAUTION:
PESTICIDES

These questions are discussed in the risk assessment in appendix A. It documents an exhaustive study of the most up-to-date data on herbicides (and materials mixed with them for application) proposed for use in the Southern Region. This risk assessment presents information on each herbicide's toxicity, evaluates potential exposure of humans and animals to the herbicides, and then estimates the risk of harmful effects for those toxicities and exposures.

The estimates of risk take into account scientific uncertainty and account for differences in individual sensitivities by incorporating safety factors. The risk assessment discloses the modeling process used to estimate risk. Discussion of herbicide effects in chapter IV and mitigation measures for herbicides in chapter II are based largely on the scientific findings of the risk assessment.

CHAPTER II

Alternatives

CHAPTER II

ALTERNATIVES

IN BRIEF

Part A discusses how alternatives were developed. Part B describes each alternative, including methods and tools available, average treatment frequencies, and estimated acres treated. Part C lists alternatives considered but eliminated from detailed study. Part D defines each method and tool and explains how they are used. Part E describes how resources are managed and what actions are taken to lessen adverse impacts or to enhance beneficial effects. Parts F through H compare how the alternatives respond to issues and affect the environment.

A. ALTERNATIVE DEVELOPMENT PROCESS

Several alternatives were developed to respond to issues (Chapter I) and cover a broad range of possible mixes of vegetation management methods. Issues were based on public comments received in 1988 and on management concerns, and were shared with the public in November 1988. In January 1989, an interdisciplinary team considered additional public comment and developed alternatives to respond to the issues.

Each alternative conforms to the following guidelines:

1. Considers the goals, objectives, and decisions of Forest Land and Resource Management Plans;

2. Should not be constrained by funding;

3. Responds to issues (Chapter I);

4. Should be implementable by the Forest Service;

5. Conforms to Federal laws and regulations (unless the alternative contemplates a specific change in laws or regulations).

B. ALTERNATIVES CONSIDERED IN DETAIL

This section describes the amount and nature of vegetation mangement done in each alternative. First, the underlying theme of the alternative is stated. Second, the methods and tools allowed in the alternative are described. Third, based on field data, the average frequency of activities that recur every few years (fuel reduction, wildlife and range habitat improvement, corridor maintenance) is projected. Frequencies are not shown for site preparation and timber stand improvement because they usually occur once per stand rotation, not on established cycles. Finally, average number of acres treated per year by each method are estimated. These acres are only projections used to evaluate environmental effects quantitatively. They were derived by professionals familiar with vegetation management activities and environmental conditions in the field. They are displayed for all national forest lands in the area, not for individual units. Upon implementation, the actual program will be based on site-specific analysis of project and may vary from these projections.

Some activities require combination treatments to meet their objectives. In this EIS, such multi-method treatments are assigned to the method that is likely to cause the most environmental disturbance or is the more intense issue. This process avoids double-counting acres. For example, evenage site preparation is often done using herbicides along with another method, such as herbicides plus prescribed fire ("brown and burn") or ripping plus herbicides. These are counted as herbicide treatments, but the effects of both methods are analyzed.

1. Alternative A (No Action)

Theme

In this "no action" alternative, vegetation management is not done. Existing vegetation is allowed to grow without manipulation.

Methods and Tools

No treatments of any kind are allowed.

Average Frequency

None.

Estimated Program

Method	Projected Acres/Yr	Percent Total Acres Treated
Fire	0	0
Herbicides	0	0
Manual	0	0
Mechanical	0	0
Biological	0	0
	0	0

2. Alternative B

Theme

Vegetation management is restricted to treatments that achieve minimum resource objectives. This alternative was developed to respond to those who want less vegetation management done with less environmental disturbance than at present.

Number of acres treated and intensity and frequency of treatments are reduced from present levels to lessen potential adverse effects on human health and safety, non-target plants and animals, soil, and water. Acres treated per year total 2.2 percent of national forest land in the Ozark and Ouachita Mountains.

Hazardous fuel treatment occurs only when fuel buildup nears dangerous levels. Wildlife and range treatments occur to promote recovery of threatened and endangered (T&E) species and when habitat conditions seriously limit populations. Corridors are maintained when vegetation threatens safety or investments on trails, roads, and utility lines. Site preparation and timber stand improvement are done only if needed to achieve minimum stocking.

Substantial shifts from present mix of methods occur in evenage timber stand improvement (from use of herbicides to manual methods), evenage site preparation (from use of herbicides and mechanical methods to prescribed fire and manual methods), unevenage site preparation (from use of herbicides to manual methods and prescribed fire), and maintenance of County and State roads (from use of herbicides to mowing).

Additional mitigation measures beyond those presently required are applied. All mitigations listed in section II.E apply except 1.b.(7,9), 2.b.(6,7) and 2.c.(26).

Methods and Tools

Herbicides: Herbicides are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer) only. Major uses are site preparation and timber stand improvement. Selective treatments only are allowed in wildlife habitat improvement. Broadcast treatments are allowed only in site preparation and evenage pine release, roadside and utility line maintenance, and range forage improvement, and then only when site conditions require them.

Mechanical: Only low disturbance tools (mowing, chopping, shearing, ripping, scarifying) are allowed. Major uses are roadside maintenance and evenage site preparation.

Prescribed Fire: Only low intensity burns with timing and location restricted are applied by ground and aerial ignition tools. Major uses are wildlife habitat improvement, hazardous fuel reduction, and unevenage site preparation.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are site preparation, timber stand improvement, and wildlife habitat improvement.

Biological: This method is not used.

Projected Average Treatment Frequency	Area Treated	Intervals (Years)
	County/State roads	2
	T&E habitat; Trails; Gas lines	3
	FS roads	5
	Range habitat; Other wildlife habitat	6
	Hazardous fuels; Power lines	7

Estimated Program	Method	Projected Acres/Yr	Percent Total Acres Treated
	Herbicides	10,995	18.7
	Mechanical	5,565	9.5
	Fire	35,462	60.3
	Manual	6,798	11.5
	Biological	0	0.0
		58,815	100.0

Alternative B

Projected acres/year by method by program:

	Method				
Program	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	10,990	5,565	35,462	6,798	0
Fuels treatment	0	0	6,214	0	0
T&E species habitat	174	0	2,637	189	0
Other wildlife habitat	520	267	19,262	996	0
Range habitat	150	0	2,580	150	0
Trails	0	0	0	132	0
Roads-Forest Service	0	1,967	0	508	0
Roads-Co/State	84	717	0	11	0
Power lines	15	284	0	15	0
Gas lines	10	187	0	11	0
Site preparation-evenage	2,552	2,143	1,093	1,422	0
Site preparation-unevenage	5,299	0	3,676	2,015	0
TSI-evenage*	1,992	0	0	1,327	0
TSI-unevenage*	194	0	0	22	0

*--Timber Stand Improvement - Includes release, precommercial thinning, understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program	Percent Selective	Percent Broadcast
Wildlife (incl. T&E) habitat	100	0
Range habitat	80	20
Roads-Co/State	20	80
Utility (power/gas) lines	40	60
Site preparation-evenage	75	25
Site preparation-unevenage	90	10
Timber stand improvement-evenage	75	25
Timber stand improvement-unevenage	100	0

3. Alternative C (Current)

Theme	The mix of methods, number of acres treated, and intensity and frequency of treatments presently specified in Forest Land and Resource Management Plans are applied. Acres treated per year total 3.7 percent of national forest land in the Ozark and Ouachita Mountains.

Hazardous fuels are treated only by prescribed fire. Wildlife habitat and range forage improvement are done mostly by prescribed fire. Corridors are maintained mostly by mechanical and manual methods. Evenage site preparation is done mostly by herbicides and mechanical methods. Unevenage site preparation is done mostly by herbicides and prescribed fire. Timber stand improvement is done almost totally by herbicides and manual methods.

Only mitigation measures presently required apply. All those listed in section II.E apply except 1.h.(21,23), 2.a.(5,6,7,16), and 2.c.(4,5,6,13,14,17,19,26).

Methods and Tools

Herbicides: Herbicides are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer) and machine (boom sprayer, granular spreader). Major uses are timber stand improvement and site preparation.

Mechanical: Low to moderate disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, light disking) are allowed. Major uses are roadside maintenance and evenage site preparation.

Prescribed Fire: Low to high intensity burns are applied by ground and aerial ignition tools. Major uses are wildlife habitat improvement and hazard fuel reduction.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are timber stand improvement, site preparation, trail and roadside maintenance, and wildlife habitat improvement.

Biological: This method is not used.

Projected Average Treatment Frequency

Area Treated	Intervals (Years)
Trails; County/State roads	1
Gas lines	2
T&E habitat; FS roads	3
Other wildlife habitat; Range habitat	5
Hazardous fuels; Power lines	6

Estimated Program	Method	Projected Acres/Yr	Percent Total Acres Treated
	Herbicides	28,605	28.3
	Mechanical	7,868	7.8
	Fire	57,229	56.5
	Manual	7,472	7.4
	Biological	0	0.0
		101,174	100.0

Alternative C

Projected acres/year by method by program:

	Method				
Program	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	28,605	7,868	57,229	7,472	0
Fuels treatment	0	0	14,500	0	0
T&E species habitat	174	0	2,637	189	0
Other wildlife habitat	1,546	300	30,766	808	0
Range habitat	479	0	2,976	0	0
Trails	13	3	0	378	0
Roads-Forest Service	0	2,623	0	677	0
Roads-Co/State	339	1,265	0	21	0
Power lines	26	330	0	11	0
Gas lines	25	282	0	6	0
Site preparation-evenage	4,624	3,065	1,812	799	0
Site preparation-unevenage	9,925	0	4,500	1,275	0
TSI-evenage*	10,554	0	38	3,208	0
TSI-unevenage*	900	0	0	100	0

*--Timber Stand Improvement - Includes release, precommercial thinning, understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program	Percent Selective	Percent Broadcast
Wildlife (incl. T&E) habitat	100	0
Range habitat	80	20
Trails	100	0
Roads-Co/State; Railroads	10	90
Utility (power/gas) lines	30	70
Site preparation-evenage	60	40
Site preparation-unevenage	90	10
Timber stand improvement-evenage	60	40
Timber stand improvement-unevenage	100	0

4. Alternative D

Theme

Use of herbicides is eliminated. Use of other methods expands from the present to make up for the loss of herbicides. This alternative was developed to respond to those who oppose use of man-made chemicals.

Number of acres treated and frequency of treatments are at present levels, but intensity of treatments is reduced to lessen potential adverse effects on human health and safety, non-target plants and animals, soil, and water. Acres treated per year total 3.7 percent of national forest land in the Ozark and Ouachita Mountains.

The largest shifts from use of herbicides occur in site preparation (mostly to prescribed fire and manual methods) and timber stand improvement (nearly all to manual and biological methods).

Use of prescribed fire increases almost solely in site preparation. Use of mechanical methods increases mostly in site preparation. Use of manual methods increases almost totally in evenage timber stand improvement, site preparation, and wildlife habitat improvement. Biological methods are introduced in evenage pine release.

Additional mitigation measures beyond those presently required are applied. All mitigations listed in section II.E apply except for herbicides (the 2.c group).

Methods and Tools

Herbicides: Herbicide use is not allowed.

Mechanical: Only low to moderate disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, light disking) are allowed. Major uses are site preparation and roadside maintenance.

Prescribed Fire: Only low to moderate intensity burns are applied by ground and aerial ignition tools. Major uses are wildlife habitat improvement, hazardous fuel reduction, and site preparation.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are timber stand improvement, site preparation, and wildlife habitat improvement.

Biological: Livestock grazing is allowed for vegetation management only in evenage pine release.

Projected Average Treatment Frequency

Area Treated	Intervals (Years)
Trails; County/State roads	1
Gas lines	2
T&E habitat; FS roads	3
Other wildlife habitat; Range habitat	5
Hazardous fuels; Power lines	6

Estimated Program	Method	Projected Acres/Yr	Percent Total Acres Treated
	Herbicides	0	0.0
	Mechanical	11,141	11.0
	Fire	65,898	65.2
	Manual	23,092	22.8
	Biological	1,043	1.0
		101,174	100.0

Alternative D
Projected acres/year by method by program:

	Method				
Program	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	0	11,141	65,898	23,092	1,043
Fuels treatment	0	0	14,500	0	0
T&E species habitat	0	58	2,695	247	0
Other wildlife habitat	0	372	30,766	2,282	0
Range habitat	0	120	3,215	120	0
Trails	0	3	0	391	0
Roads-Forest Service	0	2,623	0	677	0
Roads-Co/State	0	1,520	0	105	0
Power lines	0	344	0	23	0
Gas lines	0	295	0	18	0
Site preparation-evenage	0	4,222	4,125	1,953	0
Site preparation-unevenage	0	1,485	10,457	3,758	0
TSI-evenage*	0	99	140	12,518	1,043
TSI-unevenage*	0	0	0	1,000	0

*--Timber Stand Improvement - Includes release, precommercial thinning, understory species treatments.

5. Alternative E

Use of mechanical methods decreases from the present, and use of prescribed fire, herbicides and manual methods increases. This alternative was developed to respond to those who oppose of soil-tilling mechanical tools.

Number of acres treated and frequency of treatments are at present levels, but intensity of treatments is reduced to lessen potential adverse effects on human health and safety, non-target plants and animals, soil, and water. Acres treated per year total 3.7 percent of national forest land in the Ozark and Ouachita Mountains.

This alternative sharply reduces the use of soil-tilling mechanical tools. Therefore, the only shifts among methods occur in maintenance of wildlife openings (from minor use of light disking to prescribed fire) and evenage site preparation (from use of mechanical methods to prescribed fire, herbicides, and manual methods). In evenage site preparation, use of ripping is reduced in favor of chopping and scarifying. Shifts do not occur in other activities, where mowing is the ony mechanical tool used.

Additional mitigation measures beyond those presently required are applied. All mitigations listed in section II.E apply except 2.c.(26).

Methods and Tools

Herbicides: Herbicides are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer) and machine (boom sprayer, granular spreader). Major uses are pine release and site preparation. Selective treatments only are allowed in wildlife habitat improvement, trail maintenance, and unevenage timber stand improvement. Broadcast treatments are allowed only in range forage improvement, roadside and utility line maintenance, site preparation and evenage pine release, and then only when site conditions require them.

Mechanical: Only low disturbance tools (mowing, chopping, shearing, ripping, scarifying) are allowed. Major uses are roadside maintenance and evenage site preparation.

Prescribed Fire: Only low to moderate intensity burns are applied by ground and aerial ignition tools. Major uses are wildlife habitat improvement, hazardous fuel reduction, and site preparation.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are timber stand improvement, site preparation, trail and roadside maintenance, and wildlife habitat improvement.

Biological: This method is not used.

Projected Average Treatment Frequency

Area Treated	Intervals (Years)
Trails; County/State roads	1
Gas lines	2
T&E habitat; FS roads	3
Other wildlife habitat; Range habitat	5
Hazardous fuels; Power lines	6

Estimated Program

Method	Projected Acres/Yr	Percent Total Acres Treated
Herbicides	29,064	28.7
Mechanical	5,996	5.9
Fire	58,366	57.7
Manual	7,748	7.7
Biological	0	0
	101,174	100.0

Alternative E
Projected acres/year by method by program:

	Method				
Program	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	29,064	5,996	58,366	7,748	0
Fuels treatment	0	0	14,500	0	0
T&E species habitat	174	0	2,637	189	0
Other wildlife habitat	1,546	267	30,799	808	0
Range habitat	479	0	2,976	0	0
Trails	13	3	0	378	0
Roads-Forest Service	0	2,623	0	677	0
Roads-Co/State	339	1,265	0	21	0
Power lines	26	330	0	11	0
Gas lines	25	282	0	6	0
Site preparation-evenage	5,083	1,226	1,916	1,075	0
Site preparation-unevenage	9,925	0	4,500	1,275	0
TSI-evenage*	10,554	0	38	3,208	0
TSI-unevenage*	900	0	0	100	0

*--Timber Stand Improvement - Includes release, precommercial thinning, understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program	Percent Selective	Percent Broadcast
Wildlife (incl. T&E) habitat	100	0
Range habitat	80	20
Trails	100	0
Roads-Co/State	10	90
Utility (power/gas) lines	30	70
Site preparation-evenage	60	40
Site preparation-unevenage	90	10
Timber stand improvement-evenage	60	40
Timber stand improvement-unevenage	100	0

6. Alternative F (Preferred)

Theme

Use of manual methods and prescribed fire increases, and use of herbicides and mechanical methods decreases, from present levels. This alternative was developed to respond to those concerned about risks to certain plants and animals.

Number of acres treated and frequency of treatments are at present levels, but intensity of treatments is reduced to lessen potential adverse effects on human health and safety, non-target plants and animals, soil, and water. Acres treated per year total 3.7 percent of national forest land in the Ozark and Ouachita Mountains.

The largest shifts among methods occur in site preparation (from use of herbicides and mechanical methods to prescribed fire and manual methods), and timber stand and wildlife habitat improvement (from use of herbicides to manual methods).

Use of manual methods increases most in evenage timber stand improvement, site preparation, and wildlife habitat improvement. Use of prescribed fire increases mostly in site preparation. Use of herbicides decreases almost totally in site preparation, evenage timber stand improvement, and wildlife habitat improvement. Use of mechanical methods decreases almost solely in evenage site preparation.

Additional mitigation measures beyond those presently required are applied. All mitigations listed in section II.E apply except 2.c.(26).

Methods and Tools

Herbicides: Herbicides are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer) and machine (boom sprayer, granular spreader). Major uses are site preparation and timber stand improvement. Selective treatments only are allowed in wildlife habitat improvement, trail maintenance, and unevenage timber stand improvement. Broadcast treatments are allowed only in range forage improvement, roadside and utility line maintenance, and site preparation and evenage pine release, and then only when site conditions require them.

Mechanical: Only low to moderate disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, light disking) are allowed. Major uses are roadside maintenance and evenage site preparation.

Prescribed Fire: Only low to moderate intensity burns are applied by ground and aerial ignition tools. Major uses are wildlife habitat improvement, hazardous fuel reduction, and site preparation.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are timber stand improvement, site preparation, and wildlife habitat improvement.

Biological: This method is not used.

Projected Average Treatment Frequency

Area Treated	Intervals (Years)
Trails; County/State roads	1
Gas lines	2
T&E habitat; FS roads	3
Other wildlife habitat; Range habitat	5
Hazardous fuels; Power lines	6

Estimated Program	Method	Projected Acres/Yr	Percent Total Acres Treated
	Herbicides	24,492	24.2
	Mechanical	7,345	7.3
	Fire	59,219	58.5
	Manual	10,118	10.0
	Biological	0	0.0
		101,174	100.0

Alternative F

Projected acres/year by method by program:

	Method				
Program	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	24,492	7,345	59,219	10,118	0
Fuels treatment	0	0	14,500	0	0
T&E species habitat	104	0	2,672	224	0
Other wildlife habitat	1,028	150	31,066	1,176	0
Range habitat	237	0	3,172	46	0
Trails	0	0	0	394	0
Roads-Forest Service	68	2,488	0	744	0
Roads-Co/State	349	1,200	0	76	0
Power lines	26	315	0	26	0
Gas lines	25	267	0	21	0
Site preparation-evenage	4,164	2,757	2,244	1,135	0
Site preparation-unevenage	8,277	168	5,393	1,862	0
TSI-evenage*	9,314	0	172	4,314	0
TSI-unevenage*	900	0	0	100	0

*--Timber Stand Improvement - Includes release, precommercial thinning, understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program	Percent Selective	Percent Broadcast
Wildlife (incl. T&E) habitat	100	0
Range habitat	80	20
Roads-Forest Service	30	70
Roads-Co/State	20	80
Utility (power/gas) lines	40	60
Site preparation-evenage	75	25
Site preparation-unevenage	90	10
Timber stand improvement-evenage	75	25
Timber stand improvement-unevenage	100	0

7. Alternative G

Theme

Use of herbicides and mechanical methods increases, and use of manual methods and prescribed fire decreases, from present levels. This alternative was developed to analyze a full range of methods and tools that would provide more effective plant control with less environmental disturbance than at present.

Number of acres treated and frequency of treatments are at present levels, but intensity of treatments is reduced to lessen potential adverse effects on human health and safety, non-target plants and animals, soil, and water. Acres treated per year total 3.7 percent of national forest land in the Ozark and Ouachita Mountains.

The largest shifts among methods occur in timber stand improvement (from use of manual methods to herbicides), evenage site preparation (from use of manual methods to herbicides and mechanical methods), and wildlife habitat improvement and unevenage site preparation (from use of prescribed fire and manual methods to herbicides and mechanical methods).

Use of herbicides increases mostly in timber stand and wildlife habitat improvement and site preparation. Use of mechanical methods increases mostly in site preparation. Use of manual methods decreases mostly in timber stand improvement and site preparation. Use of prescribed fire decreases mostly in wildlife habitat improvement and site preparation.

Aerial application of herbicides is allowed for some site preparation and utility line maintenance.

Additional mitigation measures beyond those presently required are applied. All mitigations listed in section II.E apply.

Methods and Tools

Herbicides: Herbicides are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer), machine (boom sprayer, granular spreader), and air (helicopter only). Major uses are site preparation and timber stand improvement. Selective treatments only are allowed in wildlife habitat improvement, trail maintenance, and unevenage timber stand improvement. Broadcast treatments are allowed only in range forage improvement, roadside and utility line maintenance, site preparation and evenage pine release, and then only when site conditions require them. Aerial application is allowed only in site preparation and utility line maintenance where rugged terrain or dense growth makes other methods less practical.

Mechanical: Only low to moderate disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, light disking) are allowed. Major uses are evenage site preparation and roadside maintenance.

Prescribed Fire: Only low to moderate intensity burns are applied by ground and aerial ignition tools. Major uses are wildlife habitat improvement and hazardous fuel reduction.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are timber stand improvement, unevenage site preparation, wildlife habitat improvement, and trail and roadside maintenance.

Biological: Livestock grazing is allowed for vegetation management only in evenage pine release.

Projected Average Treatment Frequency	Area Treated	Intervals (Years)
	Trails; County/State roads	1
	Gas lines	2
	T&E habitat; FS roads	3
	Other wildlife habitat; Range habitat	5
	Hazardous fuels; Power lines	6

Estimated Program	Method	Projected Acres/Yr	Percent Total Acres Treated
	Herbicides (ground)	30,788	30.4
	Herbicides (aerial)	600	0.6
	Mechanical	8 703	8.6
	Fire	55,797	55.1
	Manual	4,817	4.8
	Biological	469	0.5
		101,174	100.0

Alternative G
Projected acres/year by method by program:

	Method					
Program	Herbicides		Mech.	Fire	Manual	Biol.
	Ground	Aerial				
Projected acres/year	30,788	600	8,703	55,797	4,817	469
Fuels treatment	0	0	0	14,500	0	0
T&E species habitat	213	0	37	2,600	150	0
Other wildlife habitat	2,161	0	300	30,151	808	0
Range habitat	625	0	146	2,684	0	0
Trails	13	0	3	0	378	0
Roads-Forest Service	306	0	2,623	0	371	0
Roads-Co/State	339	0	1,265	0	21	0
Power lines	58	50	248	0	11	0
0						
Gas lines	74	50	183	0	6	0
Site preparation-evenage	4,425	500	3,363	1,812	200	0
Site prep.-unevenage	10,180	0	450	4,050	1,020	0
TSI-evenage*	11,494	0	85	0	1,752	469
TSI-unevenage*	900	0	0	0	100	0

*--Timber Stand Improvement - Includes release, precommercial thinning, understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program	Ground Applications % Selective	Ground Applications % Broadcast	Aerial Application % Selective	Aerial Application % Broadcast
Wildlife (incl. T&E) habitat	100	0	0	0
Range habitat	80	20	0	0
Trails	100	0	0	0
Roads-Forest Service	20	80	0	0
Roads-Co/State	10	90	0	0
Utility (power/gas) lines	30	70	0	100
Site preparation-evenage	60	40	0	100
Site preparation-unevenage	90	10	0	0
Timber stand improvement-even	60	40	0	0
Timber stand improvement-unev	100	0	0	0

8. Alternative H

Theme

Vegetation management is done to achieve maximum vegetation control within legal constraints. Use of herbicides broadcast at maximum rates, intensive mechanical tools, and intense prescribed fire expands from the present. This alternative was developed to establish a full range of alternatives and to respond to those who want maximum production of market goods.

Number of acres treated and intensity and frequency of treatments increase from present levels. Most of the increase in acres is due to increased treatment frequency for hazaroud fuels, wildlife habitat and range forage improvement, and corridor maintenance. But some is due to repeated timber stand improvement activities on highly productive land where competition and return on investment are greatest.

Substantial shifts from present mix of methods occur in roadside maintenance (from use of mechanical and manual methods to herbicides), utility line maintenance (from use of mechanical methods to herbicides), evenage timber stand improvement (from use of manual methods to mechanical methods and herbicides), and unevenage timber stand improvement (from use of manual methods to herbicides).

Aerial application of herbicides is allowed for most evenage pine release and utility line maintenance and some evenage site preparation.

Only mitigation measures presently required apply. All those listed in section II.E apply except 1.h.(21,23), 2.a.(5,6,7,16), and 2.c.(4,5,6,13,14,17,19).

Methods and Tools

Herbicides: Herbicides are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer), machine (boom sprayer, granular spreader), and air (helicopter only). Major uses are timber stand improvement and site preparation. More herbicides are broadcast in wildlife habitat and range forage improvement, roadside and utility line maintenance, site preparation, and timber stand improvement than in the other alternatives.

Mechanical: Low to high disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, light and heavy disking, raking) are allowed. Major uses are evenage site preparation and roadside maintenance.

Prescribed Fire: Low to high intensity burns are applied by ground and aerial ignition tools. Major uses are wildlife habitat improvement and hazardous fuel reduction.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Use of manual methods declines and occurs mostly in timber stand improvement, site preparation, wildlife habitat improvement, and trail and roadside maintenance.

Biological: Livestock grazing is allowed for vegetation management only in evenage pine release.

Projected Average Treatment Frequency

Area Treated	Intervals (Years)
Trails; County/State roads Gas lines	1
FS roads	2
T&E habitat	3
Hazardous fuels; Other wildlife habitat; Range habitat	4
Power lines	4

Estimated Program

Method	Projected Acres/Yr	Percent Total Acres Treated
Herbicides (ground)	26 740	21.2
Herbicides (aerial)	14,500	11.5
Mechanical	7,353	5.8
Fire	73,424	58.2
Manual	3,332	2.7
Biological	807	0.6
	126,156	100.0

Alternative H
Projected acres/year by method by program:

Program	Herbicides		Mech.	Fire	Manual	Biol.
	Ground	Aerial				
Projected acres/year	26,740	14,500	7,353	73,424	3,332	807
Fuels treatment	0	0	0	21,750	0	0
T&E species habitat	231	0	94	2,637	38	0
Other wildlife habitat	2,101	0	300	38,939	330	0
Range habitat	599	0	0	3,720	0	0
Trails	13	0	3	0	378	0
Roads-Forest Service	2,781	0	1,967	0	202	0
Roads-Co/State	530	0	1,074	0	21	0
Power lines	40	200	297	0	13	0
Gas lines	38	300	282	0	6	0
Site preparation-evenage	3,223	2,000	3,065	1,812	200	0
Site prep.-unevenage	10,946	0	0	4,500	254	0
TSI-evenage*	4,878	12,000	271	66	1,890	807
TSI-unevenage*	1,360	0	0	0	0	0

*--Timber Stand Improvement - Includes release, precommercial thinning, understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program	Ground Applications		Aerial Application	
	% Selective	% Broadcast	% Selective	% Broadcast
Wildlife (incl. T&E) habitat	90	10	0	0
Range habitat	70	30	0	0
Trails	100	0	0	0
Roads-Forest Service	10	90	0	0
Roads-Co/State	10	90	0	0
Utility (power/gas) lines	20	80	0	100
Site preparation-evenage	50	50	0	100
Site preparation-unevenage	80	20	0	0
Timber stand improvement-even	50	50	0	100
Timber stand improvement-unev	100	0	0	0

C. ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED STUDY

Custodial Vegetation Management: This alternative would only allow hazardous fuel reduction, corridor maintenance, and protection of threatened and endangered species to provide minimum protection for public safety and crucial investments and resources. It was eliminated because alternatives A and B adequately address the effects of low-level management.

No Prescribed Fire: This alternative would eliminate use of prescribed fire. It was developed to respond to those concerned about potential adverse effects of prescribed fire. It was eliminated because alternative A already addresses a "no fire" scenario, and because most concerns are about effects on onsite plant and animal diversity which are affected more by fire intensity than by fire's presence or absence.

In addition, prescribed fire is vital to maintain habitats for threatened and endangered species such as the red-cockaded woodpecker, and it is the only method available to reduce fuel buildups and wildfire hazards. Many people also consider it to be a natural ecological process that can be managed safely.

No Mechanical Methods: This alternative would eliminate use of all mechanical tools. It was developed to respond to those concerned about potential adverse effects of mechanical tools. It was eliminated because alternative A already addresses a "no mechanical" scenario, and because concerns center on effects on plant and animal diversity and erosion. These concerns are addressed by alternative E which sharply reduces use of soil-disturbing mechanical tools.

Decrease Herbicides Only: This alternative would sharply reduce, but not eliminate, use of herbicides. It was developed to respond to those concerned about potential adverse effects of herbicides. It was eliminated because alternatives A and D allow no herbicides and alternatives B and F reduce their use.

Increase Manual Methods Only: This alternative would reduce use of herbicides, mechanical methods, and prescribed fire. It was developed to respond to those concerned about potential adverse effects of these methods. It was eliminated because other alternatives adequately address reduced use of all these methods.

D. DESCRIPTION OF METHODS AND TOOLS

This section describes methods and tools proposed for use in the vegetation management program. Methods discussed are prescribed fire, mechanical, manual, herbicides, and biological. Regardless of the harvest cutting methods identified in Forest Land and Resource Management Plans, all of the tools described in this section are available for use as specified by each alternative.

1. Prescribed Fire

Prescribed fire is the planned use of fire. It is used to reduce hazardous fuels, prepare sites for seeding or planting, rejuvenate wildlife and range forage species, maintain fire-dependent species and ecosystems, control insects and diseases, and manage wilderness and threatened and endangered species and their habitat. Factors evaluated when using prescribed fire include project objectives, fuels (quantity, type, distribution, moisture content), topography (ruggedness, elevation, slope), weather (temperature, wind, humidity), time of year, smoke dispersal, and predicted fire behavior (flame length, rate of spread).

Firing techniques are the patterns used to dispense fire. The six techniques commonly used are backing fires, strip-head fires, flanking fires, spot fires, ring fires, and slash pile or windrow fires (figure II-1).

Backing fires consist of burning a fire against the wind. Strip-head fires are a series of parallel lines of fire set against the wind, perpendicular to wind direction; lines burn with the wind but never gain momentum before burning into the next line. Flanking fires are a series of lines of fire set against the wind, parallel to wind direction, that burn out at right angles from the wind direction. Spot fires are a series of parallel fire spots (approximately 50 to 250 feet apart) set against the wind. The fires radiate out in all directions, minimizing fire momentum as they burn together. Ring fires are applications of a single line of fire completely around burn areas. Slash pile or windrow fires are applied to concentrated fuel piles.

Three types of ignition tools are commonly used in the Ozark/Ouachita forests. The traditional ground-based system is the hand-held drip torch. The other two tools, which are aerial ignition systems, are the helitorch and plastic sphere dispenser. Choice of firing technique and ignition tool depends on project objectives, site conditions, and safety.

a. Hand-held Drip torch

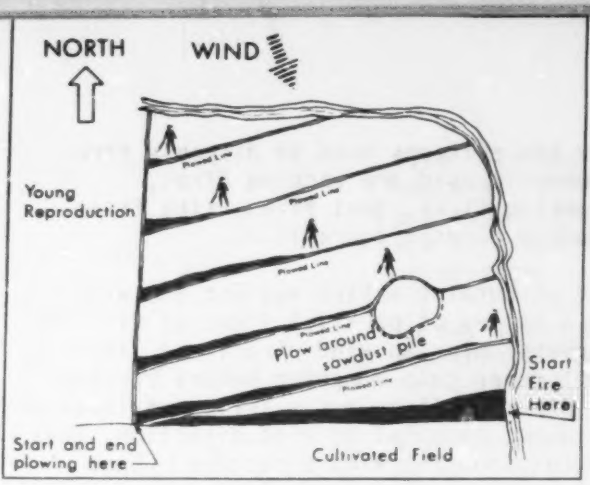
Drip torches are small hand-held aluminum or stainless steel tanks that contain a mixture of gasoline and diesel fuel. A spout attached to the tank drips the fuel mixture onto a lighted wick. Lighted fuel falls to the ground igniting surface fuels. All six firing techniques can be applied using hand-held drip torches.

b. Helitorch

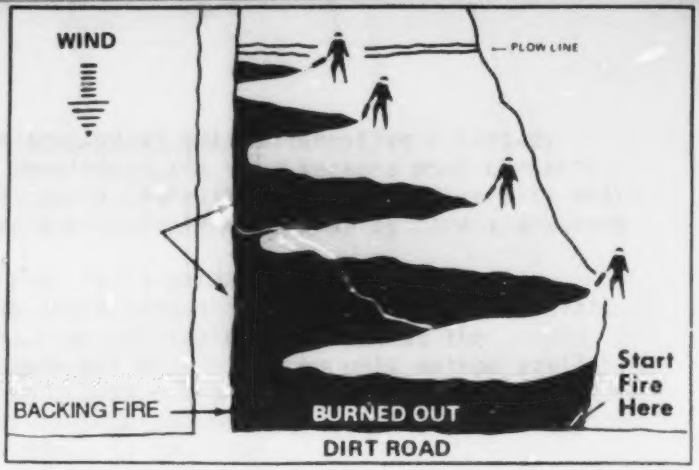
Helitorches are specially designed drip torches for application of ignited gelled fuel from helicopters. They consist of a 30- or 50-gallon fuel drum, an ignition and electric pump assembly, and frame and suspension system. The helitorch is suspended laterally beneath and to the front of a helicopter. The nozzle end of the torch is positioned on the same side as the pilot. The pilot controls flow and ignition of the gelled fuel. Gelled fuel is formed by adding a fuel thickening powder to regular gasoline or a 70-30 mixture of diesel fuel and gasoline. The strip-firing technique is most commonly used, although a helitorch can be used with all firing techniques.

c. Plastic Sphere Dispenser

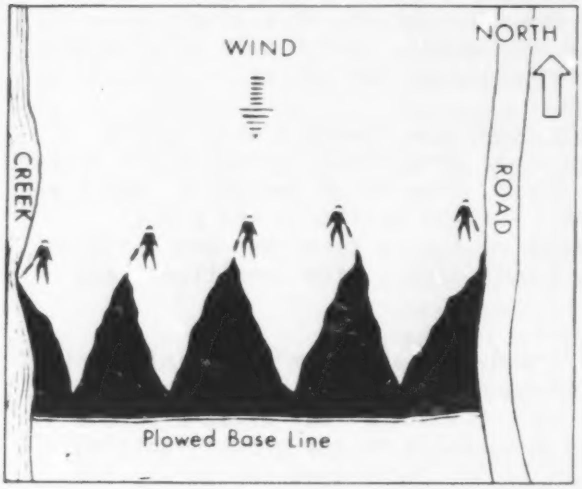
The plastic sphere dispenser is also applied using helicopters but the tool is mounted just inside the side door of a helicopter. The device ejects small spheres (commonly called "ping-pong balls"), made of high-impact polystyrene, approximately 1.25 inches in diameter, and filled with 3 grams of potassium permanganate (a dark purple salt used as an oxidizer). Immediately prior to ejection,


NORTH
WIND
Young Reproduction
Plowed Line
Plowed Line
Plowed Line
Plowed Line
Plow around sawdust pile
Plowed Line
Start Fire Here
Start and end plowing here
Cultivated Field

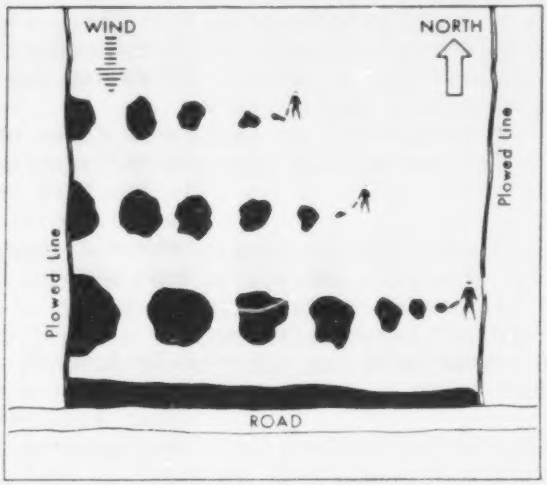
BACKING FIRE TECHNIQUE


WIND
PLOW LINE
BACKING FIRE
BURNED OUT
DIRT ROAD
Start Fire Here

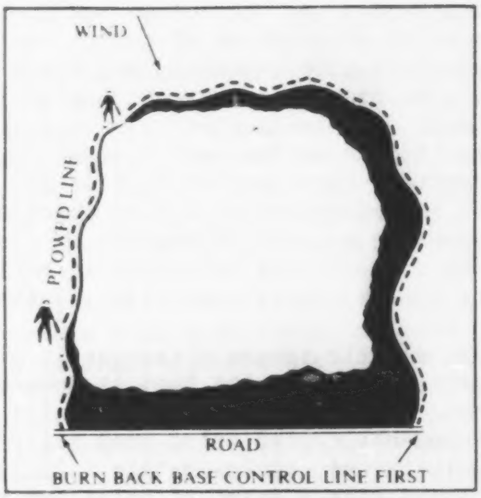
STRIP-HEAD FIRE TECHNIQUE


WIND
NORTH
CREEK
ROAD
Plowed Base Line

FLANK FIRE TECHNIQUE


WIND
NORTH
Plowed Line
Plowed Line
ROAD

SPOT FIRE TECHNIQUE


WIND
PLOWED LINE
ROAD
BURN BACK BASE CONTROL LINE FIRST

RING FIRE TECHNIQUE

Figure II-1.--Firing techniques.

the spheres are injected with about 1 milliliter of ethylene glycol (antifreeze). Spheres are dropped onto the treatment area at predetermined spacings (one or more per acre). After a delay of approximately 20 seconds, a reaction between the two chemicals ignites the sphere which sets fire to the surface fuels. The spot-firing technique is applied when using the plastic sphere dispenser.

2. Mechanical Methods

Eight types of mechanical tools are used on the Ozark/Ouachita forests. They are divided into three categories based on their potential for soil disturbance by erosion, compaction, and nutrient loss. Potential soil disturbance is low for mowing, chopping, shearing, scarifying, and ripping tools; moderate for piling tools; and high for raking and disking tools.

a. Mowing Tools

Mowing tools are rotary cutting devices that cut, chop, or shred vegetation on slopes up to 30 percent. Herbaceous species (grasses, grass likes, forbs) as well as woody species (vines, shrubs, trees) are cut near the ground line and are mulched and scattered, facilitating on-site decomposition and nutrient cycling. These tools are most effective on vegetation 3 inches or less in diameter. They are commonly used to maintain road and utility rights-of-way, refurbish wildlife food plots, and precommercially thin young stands. Since mowing tools cut vegetation above the ground line, little soil is disturbed.

Sprouting species require repeated treatments because they rapidly recover and compete with desirable vegetation. In addition, as the material is cut it can be ejected from the machine causing a safety hazard to workers or bystanders.

b. Chopping Tools

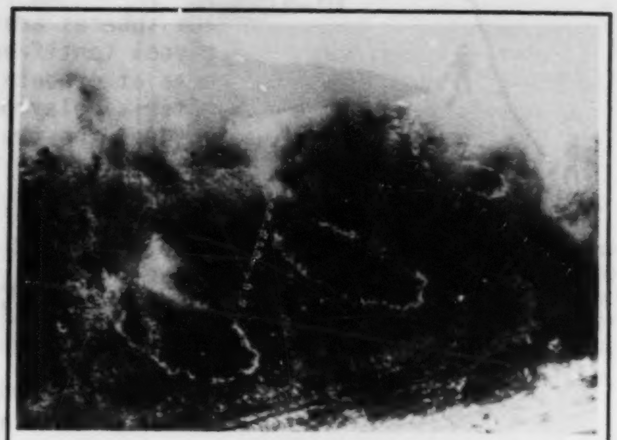
The most common chopping tool is a single rolling drum chopper towed by a crawler tractor. It cuts and chops herbaceous and woody vegetation up to 5 inches in diameter and operates on slopes up to 35 percent. Vegetation is pushed to the ground and cut into small pieces as the chopper rolls over it. Chopping tools are used mainly for site preparation but they are also used for rights-of-way maintenance and precommercial thinning.

Vegetation is cut and chopped into small pieces, which helps decomposition and nutrient cycling. Depressions made by chopping blades also increase water infiltration and mixing of organic matter into the soil. Soil exposure and disturbance are minor.

Release treatments may be needed because of rapid recovery of sprouting species, and debris left in place may impair planting. Soil exposure can be significant at the upper end of the tool's slope range.

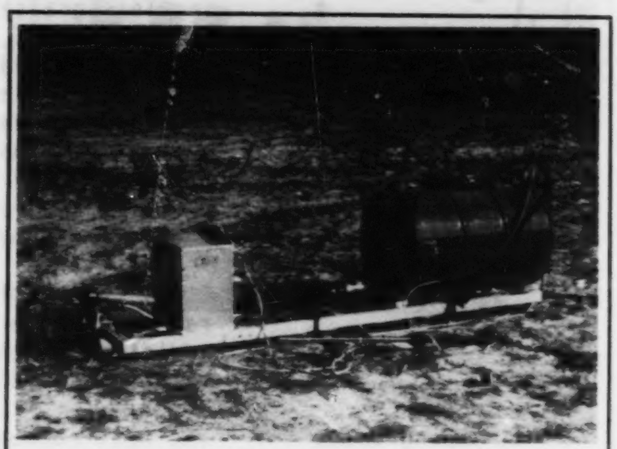
PRESCRIBED FIRE TOOLS

Aerial Ignition Device



Spot firing technique

Helitorch in operation



Helitorch

Hand held drip torch

Helitorch

c. Shearing Tools

Shearing tools are specialized cutting blades mounted on crawler tractors. The two types used are K-G ("angle") blades and V-blades. They are used on slopes up to 35 percent. Any size of herbaceous and woody vegetation can be cut just above the ground line. This equipment is used for site preparation and provides a cleared area ready for direct seeding or planting.

As material is pushed aside, topsoil can be displaced, which increases risk of erosion. Sprouting species recover quickly and compete with desired vegetation.

d. Scarifying Tools

Scarifying tools clear herbaceous and small woody vegetation; their rotating scalping blades form a shallow depression, 2-4 inches deep, with an adjacent pile of topsoil. The modified area is approximately 18 inches by 3 feet. Size and spacing of scalped areas can be varied. On the average, cleared areas are on a 7-foot by 7-foot spacing. Scarifiers are usually towed behind a crawler tractor or rubber-tired skidder on slopes up to 35 percent. They are used mainly for site preparation.

Scarifiers modify soil moisture and nutrient conditions. Depressions increase water storage, and adjacent piles have increased soil drainage and concentrated nutrients. Cleared areas are not continuous and ground cover between them is usually not disturbed, so risk of erosion and nutrient loss is very low.

Efficiency of scarifiers is reduced on steep slopes, shallow soils, and sites having many obstacles such as large rocks, stumps, or logs. Additional treatments, such as herbicide application alongside scalped areas or subsequent release after seeding or planting, may be necessary on sites with abundant understory vegetation to reduce competition around cleared areas.

e. Ripping Tools

Ripping tools (also called subsoilers or chisel plows) are large blades or shanks pulled through the soil at depths of 4 to 20 inches. Spacing between rips varies from 3 to 12 feet. The exposed soil ranges from 6 to 24 inches wide. Because of the blades' size and tilling depth, rippers are usually mounted on or pulled behind large farm or crawler tractors. Ripping is usually done on the contour of slopes up to 35 percent. Rips placed on the contour can be continuous, but rips not on the contour are broken up by lifting the blades out of the ground every 50 to 100 feet. Some wildlife habitat improvement projects use rippers, but they are mainly used for natural or artificial site preparation.

Rippers break up and mix compacted soils and improve soil porosity. This action forms a microsite more suitable for seeding or planting by improving soil drainage and available moisture. Risks of erosion are very low when ripping is done on the contour, as the undisturbed area between rips and the contour berms trap nearly all eroded soil. Such risks increase when done up and down slopes.

High amounts of logging slash, standing residual trees, or woody understory vegetation reduce ripping efficiency. Treatments such as prescribed burning or shearing and piling prior to ripping may be necessary on such sites to facilitate ripping.

f. Piling Tools

Piling tools move logging slash and woody understory vegetation into piles or windrows. The piling tool is commonly called a brush rake or piling and stacking rake. It replaces the dozer blade on a crawler tractor and is used on slopes up to 35 percent. It is not solid like a standard dozer blade, but consists of a series of curved teeth spaced at intervals of 6 to 24 inches. The rake is held above the soil surface, and logging slash and brush are rolled forward into piles or windrows. Piling tools are used mainly for preparing sites for artificial regeneration.

Teeth of the rake do not penetrate the soil and are curved to produce a rolling motion of material being piled, which creates a moderate amount of soil disturbance. As the material is rolled forward, nearly all topsoil and much litter filter through the spacings between the rake teeth.

g. Raking Tools

Raking tools also move logging slash and woody understory vegetation into piles or windrows. Rakes are standard dozer blades or brush rakes mounted on a crawler tractor. They can operate on slopes up to 35 percent. Raking tools are used mainly for preparing sites for artificial regeneration.

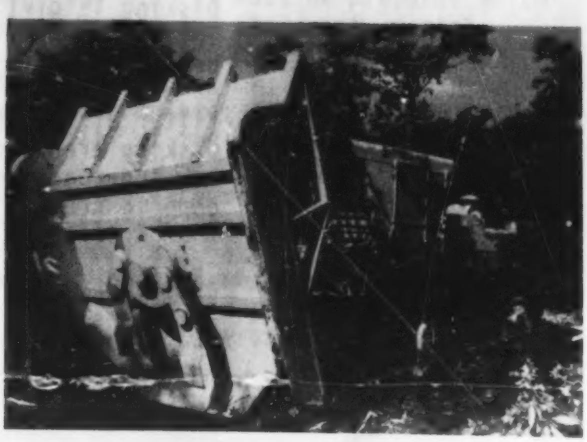
Raking differs from piling. A standard solid dozer blade pushes material forward with little rolling action. This action causes logging slash, brush, litter, and some topsoil to be scraped into the piles or windrows. When using a brush rake, the teeth are lowered to penetrate the soil, uprooting and pushing herbaceous and small woody vegetation ("root-raking") as well as litter and some topsoil along with the logging slash and brush into the piles. Soil disturbance from raking is high.

h. Disking Tools

Disking tools consist of one or more sets of disks pulled behind a farm or crawler tractor. Disks plow by tilling and mixing topsoil and litter to depths of 4 to 20 inches. Disking is usually done on the contour on slopes up to 30 percent. Disking tools are used for wildlife and range habitat maintenance and for preparing sites for artificial regeneration.

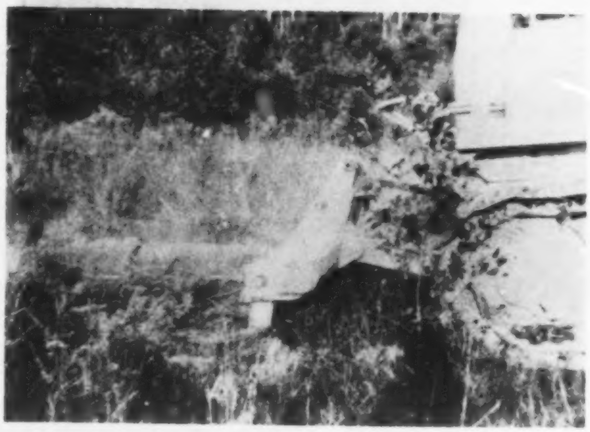
MECHANICAL TOOLS (1)

Mowing tool - Shredder



Mowing tool - Hydro Axe

Mowing tool - Bush-hog



Ripping tool

Scarifying tool

Scarifying tool

Disking is divided into light and heavy categories based on intensity of tilling. Light disking is done to shallow depths on small areas (usually less than 1 acre), in strips, or on slopes of 5 percent or less. Undisked strips act as filter strips that reduce soil loss. Examples of light disking are wildlife opening refurbishment and reseeding of logging roads and skid trails. Heavy disking is commonly done to greater depths over large areas at slopes steeper than 5 percent.

Efficiency of disking is reduced on areas with many obstacles, such as large rocks, logs, or stumps, which could damage disks. On areas with heavy logging slash or abundant brush, common treatments prior to disking include shearing followed by piling or raking. Disking can break up compacted surface soils.

3. Manual Methods

Manual methods use hand-operated powered or non-powered tools to cut, clear, thin, girdle, or prune herbaceous and woody species. Non-powered hand tools are axes, brush hooks, and hand clippers. Powered hand tools include chain saws and motorized brushcutters (weed eaters with a saw-type blade). Slope does not limit use of manual tools. Manual tools are most commonly used for timber stand improvement (release, precommercial thinning), corridor maintenance (especially trails), wildlife and range habitat improvement, and threatened and endangered species habitat improvement.

Manual cutting tools sever vegetation above the ground line; soil is seldom exposed. Residues are usually left intact on the treatment area, facilitating nutrient cycling as the materials slowly decompose. Heavy amounts of slash may initially cause an increase in fire hazard. Sprouting species rapidly recover and compete with desirable vegetation, requiring repeated manual treatments or the use of other treatments such as herbicides or prescribed fire.

4. Herbicide Methods

Characteristics of the 7 herbicides used in the Ozark/Ouachita Mountains are described below, as are 3 application methods: (1) manual ground, which uses hand-carried equipment; (2) mechanical ground, which uses truck- or tractor-mounted equipment; and (3) aerial, which uses helicopter-mounted equipment.

Herbicides are applied as either liquid sprays or granules. All spray-application tools are designed to produce large droplets to minimize drift. Relatively large and heavy granules are also designed to minimize drift.

New herbicides and application methods are periodically registered for silvicultural use. Prior to operational use, efficacy of the herbicide is evaluated through research and administrative studies on small areas. If the product is effective, a supplement to this EIS must be prepared which includes a toxicological background statement, a risk assessment, and analysis of the product's environmental behavior. Once testing, documentation, and public disclosure of findings are complete, field personnel are notified of the availability of the new herbicide or tool.

a. Herbicides Characteristics

Primary sources of information are product labeling information, material safety and technical data sheets, the Weed Science Society of America's Herbicide Handbook (1983), and the Southern Region's annual herbicide use reports. Individual sources are not cited for each bit of data.

FOSAMINE

TRADE NAME: KRENITE^R, KRENITE^R S.

Fosamine ammonium is labeled for non-cropland brush control on railroads, rights-of-way, industrial plant sites, drainage ditch banks, etc., including land surrounding water supply reservoirs. In forestry it is seldom used, but is used for right-of-way maintenance. Method of application is foliar spray, and coverage must be complete to be effective. Fosamine is absorbed by foliage, stems, and buds of broadleaf plants. The effects of this herbicide are delayed, and following a fall application, bud development in the spring is prevented or severely limited. There is little or no leaching of fosamine through soil. Field tests have shown a half-life in soil of about 1 week.

GLYPHOSATE

TRADE NAME: ROUNDUP^R, RODEO^R, ACCORD^R, and others.

Glyphosate is commonly used in agriculture and as a home-use product. It controls a broad range of grasses, weeds, and woody brush species. Roundup is registered for uses on orchards, groves, vineyards, and in weed control prior to planting of grains, soybeans, corn, and other food crops. It is also registered for control of grass and weeds in recreational areas, schools, parking lots, other public grounds, and for non-crop areas, forests and silvicultural sites. Rodeo is labeled primarily as an aquatic herbicide, but is also labeled for forestry. Accord is registered for use on forest and industrial sites. Glyphosate is used in forestry for site preparation and release. Methods of application include cut-surface treatments and foliar spray. Glyphosate is readily absorbed by foliage and primarily affects plants by disrupting photosynthetic processes. Glyphosate has practically no leaching tendency because it binds tightly to soil. In soil, it is highly susceptible to degradation by micro-organisms, being converted to natural products such as carbon dioxide and water. Persistence in soils is about 2 months or less.

MECHANICAL TOOLS (2)

Tandem rolling drum chopper

Single rolling drum chopper

Disking tool

Shearing tool, V-blade

Piling tool - brush rake

Piling tool - brush rake

HEXAZINONE

TRADE NAME: VELPAR^R L, Velpar^R ULW, PRONONE^R 5G, PRONONE^R 10G, and others.

Hexazinone is used to control a wide variety of grasses, weeds, and woody plants. Hexazinone has a number of food crop uses including weed control in blueberries, sugarcane, pineapple, and alfalfa. In forestry, it is commonly used for site preparation and release. Methods of application include foliar spray, basal soil applications, granular applications to soil, and cut-surface treatment. Hexazinone is a "soil-active" herbicide, moves readily through soil, and is absorbed by plant roots with some foliage absorption. Herbicide activity and lateral and vertical movement is limited in soils high in organic matter or heavy clay. It may affect nearby desirable plants outside the treated area which have roots growing into the treated zone. Hexazinone primarily affects plants by inhibiting photosynthesis. The degree of effect on plants depends on susceptibility of the species, rate of application, and soil texture. In soil, hexazinone is subject to microbial degradation. It persists in soil from 1 to 6 months depending on soil and weather.

IMAZAPYR

TRADE NAME: ARSENAL^R, ARSENAL^R Applicators Concentrate, CHOPPER^R, and others.

Imazapyr is used for control of weeds, grasses, and woody plants in forestry including site preparation and release. It is also labeled for weed control under pavement at industrial sites and rights-of-way. Methods of application include cut-surface treatments, foliar spray, and basal bark spraying. Imazapyr is absorbed through foliage and roots and is rapidly moved throughout the plant. Imazapyr accumulates in growing tips of plants where it inhibits amino acid synthesis. It affects susceptible species slowly, yellowing newest leaves first and then spreading throughout the plant. Imazapyr can enter the soil, but lateral and vertical movement is limited. It persists in soil up to 12 months depending on soil type, amount used, and weather. It may affect nearby desirable plants outside the treated area which have roots growing into the treated zone. Imazapyr photodegrades and, to a lesser extent, biodegrades. Imazapyr has minimal effect on soil microflora.

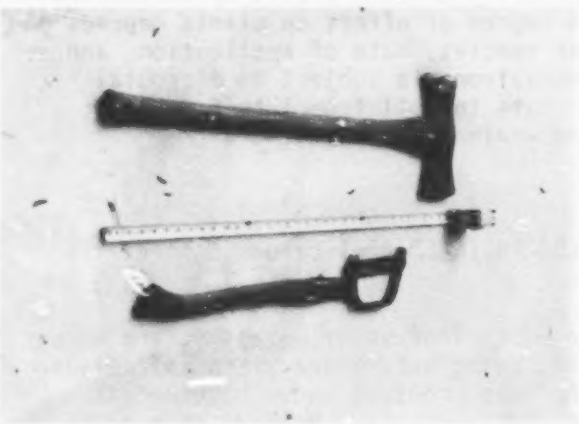
PICLORAM

TRADE NAME: TORDON^R K and others (but not formulations with 2,4-D).

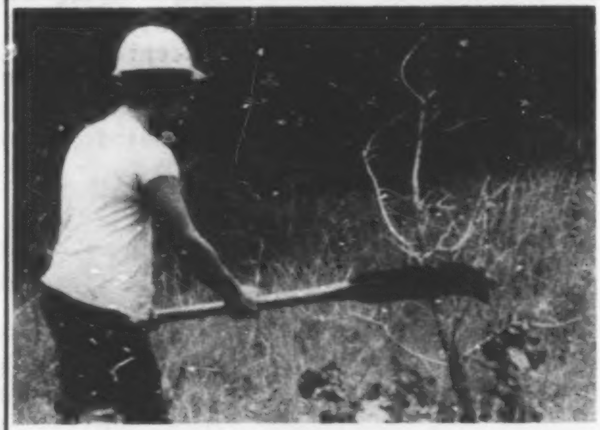
Picloram's uses include noxious weed control, rights-of-way, facilities maintenance, and rangeland improvement. In forestry it is used to control woody plants and weeds.

Cattle as a biological control tool

Powered hand tool - chainsaw



Brush axes



Brush hook

Brushsaw

Cattle as a biological control tool

Methods of application include cut-surface treatments and foliar spray. Picloram is primarily a growth regulator. Herbicidal action is a result of absorption through leaves and some uptake through roots. It is easily translocated in plants and accumulates in new growth causing leaves to cup and curl. Picloram is water soluble and can move in sandy soils low in organic matter. It may affect nearby desirable plants outside the treated area which have roots growing into the treated zone. Degradation by soil micro-organisms is slow and primary breakdown is by ultraviolet light. Persistence in soils varies by type of soil and weather but may exceed 100 days.

SULFOMETURON METHYL

TRADE NAME: OUST^{R}.

Sulfometuron methyl is a broad spectrum, pre- and post-emergence herbicide. Its labeled uses include selective weed control in turf grass, roadsides, and other non-cropland applications. It is registered for control of undesirable herbaceous plants in pine reforestation sites. The method of application normally is foliar spray. Sulfometuron methyl is absorbed through plant leaves, with some absorption by roots. In the plant, it suppresses and stops plant growth by arresting cell division in growing tips. Sulfometuron methyl is hydrolyzed in soil and persists approximately 4 weeks.

TRICLOPYR

TRADE NAME: GARLON^{R} 3A, GARLON^{R} 4, and others.

Triclopyr is a broad-spectrum herbicide originally developed for control of vegetation along utility rights-of-way and on industrial sites. In forestry, it is labeled for site preparation and release. Methods of application include cut-surface treatments, foliar spray, and basal bark spray. Triclopyr is primarily absorbed by plant leaves and is readily moved throughout the plant. It affects plants by interfering with normal growth processes. In soil, triclopyr is not highly mobile. It is rapidly broken down by soil micro-organisms and ultraviolet light, persisting an average of 30-56 days depending on soils and weather. Its half-life in water is about 10 hours at 72°F.

b. Manual Ground Tools

Tools used for manual ground application deliver herbicide in a variety of ways. Application of liquids includes basal, soil-spot, foliar, and cut-surface treatments. Granules can be applied by hand or a hand-held spreader.

Liquid Application

Basal applications are used for release, precommercial thinning, and right-of-way maintenance, though some site preparation work is also done this way. A spray gun or wand is used to direct the spray at a target stem. Two types of basal applications are used:

- Full basal treatments are applied to trees up to 5 inches in diameter. The lower 12 to 20 inches of the stem are wet with herbicide on all sides.

- Streamline treatments are applied to smaller juvenile stems. Herbicide is applied to one side of the stem in a 1.5- to 2-inch band.

Soil-spot applications are used for site-preparation and release (and some right-of-way) treatments. A soil-active herbicide is sprayed onto the soil in the treatment area. Three basic patterns of spray application are commonly used:

- Spot grid treatment is commonly used on sites with many stems per acre. Spots of herbicide are applied to the soil in a regular pattern.

- Individual stem treatment is applied by spraying the soil around unwanted plants.

- Spot-around treatments are made by spraying herbicide spots on the ground around the desired plant.

Foliar applications are generally used to release 3-year-old or younger stands from competition. Liquids are sprayed onto leaves of target plants in full leaf and growing.

- Directed foliar spray application is used to release young stands from competition that is less than 6 feet tall. Herbicide is generally applied to hit target vegetation but miss desired plants.

- Herbaceous weed control is done by applying herbicide directly over the top of all plants including desired plants to control competing vegetation. Herbicide is sprayed in a 4-5 foot circle or in a continuous band.

Cut-surface treatments are used to eliminate competing trees or control resprouting of stumps during site preparation, precommercial thinning, and release. Three types of treatments are used:

- Tree injection, in which herbicide is placed directly within the wood of a tree by an injector, is most efficient on sites with sparsely distributed stems greater than 2 inches in diameter.

- Frill or girdle treatments involve cutting through the bark with an axe or hatchet to expose the cambium. The cut surface is then completely wet with herbicide. Girdles are formed by a completely encircling ring of cuts. Frilling generally results in a less complete ring of cuts.

- Cut-stump treatments are applied to stumps of any size to reduce sprouting. A sprayer is used to thoroughly wet the cambial area (about the outer 1 inch) of the stump.

Spray solutions are normally carried in backpack tanks, which hold between 1 and 5 gallons. These tanks have a diaphragm pump with a lever which allows the worker to pressurize the tank. Herbicide is applied to the target via a hand-held gun or wand attached to the tank by a flexible hose. Within the gun or wand mechanism is a valve system controlled by a trigger, which allows the worker to start or stop application of the chemical. Application is made as a continuous flow or as a predetermined volume of liquid per pull of the trigger. Depending on type of nozzle used in the gun or wand, a large-droplet spray or a continuous stream of liquid is delivered.

The purpose of the project determines the type of tool used. To fully cover foliage (broadcast application), a gun or wand which dispenses a continuous flow of chemical through a spray nozzle is commonly used. Should a directed spray be desired (selective treatment), a spotgun or wand and a stream nozzle are most commonly employed. When treating freshly cut stumps, a continuous stream of herbicide from a spotgun or wand is used to soak the cambial area of the stump.

Sprays can drift, while continuous streams can splash back off the target vegetation. Tank weight makes the worker more subject to tripping in uneven terrain. Improperly maintained equipment is likely to leak on the worker. The hose between the backpack and hand unit can snag on vegetation and break, causing a spill of chemical directly onto the worker.

Tree injectors are closed hollow tubes (liquid tanks) which are refilled at the top and deliver liquid through a valve at the bottom. The valve end of the injector has a 1 to 2 inch blade used to cut through tree bark to expose the cambium. The injector is jabbed into a tree, a lever or string (trigger) is pulled, and herbicide is delivered into the cut.

A second form of injector is a modified hatchet called a hypo-hatchet. The cutting edge is about 1 to 2 inches wide and a hose and valve system are added. The hose connects the hatchet with a container attached to the applicator's belt. Herbicide is discharged into the cut by gravity and a piston system each time the hatchet is used.

A combination of injection and spraying using an axe and hand-held sprayer is called hack-and-squirt. A narrow-bladed hatchet is used to cut the bark of the target tree and a squirt bottle (held in the other hand) is used to apply herbicide to the cut.

All injection methods are target specific and are useful where selectivity is desired. These tools are most efficient where target plants are sparsely distributed and stems are larger than 2 inches in diameter.

Injecting trees is a labor-intensive activity, so worker fatigue and safety can become limiting. Injector nozzles clog with bark and wood chips and need to be cleaned frequently. Splash from injecting into cuts causes the tool to become coated with herbicide during the workday. The hypo-hatchet is very sloppy if not carefully maintained. Moreover, workers can be exposed to spray during the cut stroke and when the tool is removed from the cut. Squirt bottles used in hack-and-squirt are difficult to maintain and leak after only limited use.

Granule Application

Granules are manually applied by hand or hand-held spreaders. Treatments can be either selective or broadcast.

- Broadcast treatments scatter herbicide granules in a relatively uniform pattern over the treated area.
- Selective treatments locate target and non-target vegetation and place the granules either near target plants (to reduce their growth), or away from a desirable plant (to release it as in spot-around).

To hand-spread granules, only a sack and personal protective equipment are needed. Wearing gloves, workers carry the herbicide in a sack and throw the granules onto the ground. Hand-held spreaders are generally fertilizer spreaders: hoppers with a crank-operated rotating disk attached below. Granules pass through a small opening in the hopper onto the disk and are thrown from it when the crank is turned.

Granules are most commonly applied for site preparation, release, or right-of-way maintenance. They pose less risk to workers than liquid herbicides since there is less exposure to the herbicide (appendix A).

Granules require rain to release them into the soil where they become active, but they are subject to surface runoff in heavy rainfall. Additionally, they can bounce on impact and often tend to roll to the bottom of a furrow. This localized accumulation of granules can result in uneven control of vegetation.

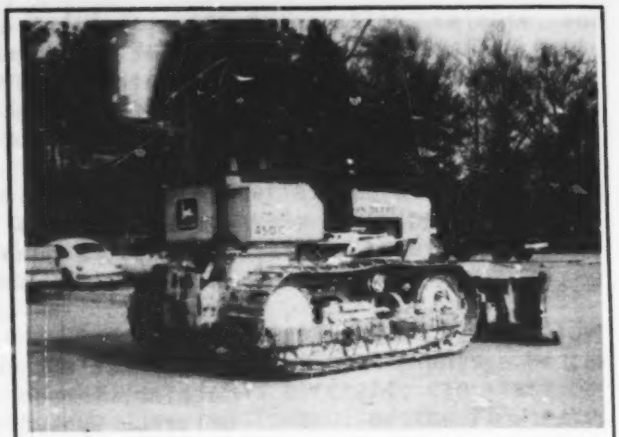
c. Mechanical Ground Tools

Many mechanical systems are available to apply herbicides. Units are available to mount on crawler or rubber-tired tractors, skidders, tree shearers, or truck beds.

Mechanical ground equipment is normally designed to broadcast granules or sprays. Risk of exposing the applicator to herbicide is less than for manual ground methods. In addition, fewer workers are required.

HERBICIDE TOOLS

Injector



Granular spreader

Hypo-hatchet

Backpack sprayer with spotgun attachment

Axe and sprayer

Helicopter spraying

All mechanical ground tools are subject to site-related restrictions; slope, soil, and proximity to streams must be evaluated to determine tool suitability. These methods allow for large-area coverage in a relatively short time, but they are not target selective.

Liquid Application

Mechanical tools for dispensing liquid herbicides have some common features. All have a tank (generally 25-300 gallons), a pump, a delivery system which controls the flow of herbicide, and nozzles which produce large spray droplets. The shape of many parts and overall configuration of the tool vary greatly, based on economics and proposed use. Most sprayers are controlled by the driver of the machine, though some require an operator in addition to the driver. Sprayers are commonly mounted on crawler tractors for use in forestry settings, though rubber-wheeled tractors or skidders are sometimes used. For roadside maintenance, truck-mounted units are most common.

Fixed-position booms similar to those used for agriculture (20-foot-wide boom with as many as 21 nozzles mounted at uniform intervals) are sometimes used in forestry or right-of way maintenance. It is, however, more common to see one or two clusters of "raindrop"-producing nozzles mounted on a short movable boom. A long boom (15 feet) has been developed for doing release work in heavily wooded areas. The boom is mounted vertically at the back of a crawler tractor with the nozzles broadcasting herbicide down onto vegetation.

The most common application pattern for mechanical sprayers is broadcast spray in narrow or wide bands. Electric systems, however, allow operators to vary position of boom and placement of spray with a fair degree of accuracy. Electric boom-positioning controls are more common on units designed for roadside maintenance.

Granule Application

Granule spreaders are large, rugged units powered by the machine on which they are mounted or by an independent power source. The spreaders either throw or blow the pellets through a dispensing tube.

They are used primarily for site preparation or release where broadcast application is appropriate. Granules tend to bounce and roll on impact, often rolling together in small depressions. This can cause spotty results or too much herbicide in one area.

d. Aerial Tools

Application by helicopter is the only aerial method evaluated. Granules and liquids can be applied aerially. The herbicide tank or hopper is mounted outside the cabin, reducing pilot exposure to the chemical. Due to the large amount of herbicide which can be applied daily, the mixer/loader faces greater exposure risk than in a mechanical ground project. Aerial application requires very few workers.

Aerial methods are useful for site preparation, release, and right-of-way maintenance. Aerial delivery systems are most effective on larger areas. Due to buffer requirements and economics, aerial treatment is rarely practical for less than 20-acre blocks.

Drift is a primary concern during aerial operations. Uniformly large droplets and relatively heavy pellet weight sharply reduce drift. Care must be taken, however, to ensure proper safety standards.

Aerial operations are broadcast applications, and the pilot has limited ability to treat specific target plants. He can manipulate position and speed of his aircraft, can start or stop herbicide flow, and often has control of the flow rate of the herbicide. But these controls are rather inexact when compared with manual ground applications. Selection of the proper herbicide is critical to the success of an aerial application project.

Liquid Application

Aerial systems for applying liquids are boom/nozzle systems such as the microfoil boom. The system generates streams of liquid which, in the wake of the boom, break into droplets as a result of air turbulence. Droplets formed in this manner are relatively large and uniform. Another system being tested (through-the-valve boom or TVB system) is also designed to generate large droplets. Booms are mounted in static air below and in front of the helicopter; but flow is controlled by the pilot. Herbicide tanks used in the Region contain a maximum of 100 gallons.

Granule Application

A specially designed spreader is suspended below the helicopter. Air flow through the mechanism distributes the granules in the helicopter's wake. The hopper and feed mechanism is outside the cabin but controlled by the pilot.

5. Biological Methods

Biological methods intentionally use living organisms to suppress, inhibit, control, or eliminate growth of herbaceous and woody vegetation. For the purpose of this EIS, only grazing by domestic livestock within current grazing allotments that can effectively contain the animals is evaluated as a viable biological control method.

Researchers are currently evaluating other potential methods of biological control. Some experimental methods show promise but are not yet operational for forestry. These methods include microbial and viral agents (biological herbicides); plant pathogens, insects, nematodes, genetics (natural adaptability and plant breeding); competition (interspecific); allelopathy (plants affecting other plants through chemical inhibitors); and biodegradable mulches. When any of these methods is determined to be successful at operational levels, it will be evaluated for use in the vegetation management program. Its use will then be coordinated through all applicable State and Federal programs and regulations.

On national forests, domestic livestock such as cattle, horses, sheep, and goats are in limited use as biological control methods primarily in the western United States. Little use has occurred in this Region. The objective is vegetation control through prolonged grazing, not animal weight gain. Numbers of livestock in an area are increased to a point where target vegetation is effectively controlled. Once the project objective is achieved, stocking levels are returned to normal allotment guides.

Effectiveness of grazing for vegetation control depends on size of area, amount of control needed, types and amounts of herbaceous and woody species present, and feeding selectivity of animals used. For example, on an area where herbaceous species are to be controlled, cattle may be appropriate because they are more likely to graze grasses, grass-like plants, and forbs. Where woody species are to be controlled, goats may be more appropriate because a higher component of their diet consists of woody browse species.

Desirable herbaceous and woody species are susceptible to overbrowsing and trampling. Moreover, risks of soil erosion and compaction are high from overgrazing. Conflicts with wildlife can also occur in areas with habitat limitations or restrictions (such as seasonal food shortages). Location of water sources, proper fencing or herding requirements, availability of livestock, and economics can also be limiting factors.

E. MANAGEMENT REQUIREMENTS AND MITIGATION MEASURES

This section describes management requirements and mitigation measures. Management requirements set direction on how resources are managed (such as timber stocking standards). Mitigation measures are actions taken to lessen adverse impacts or enhance beneficial effects (such as streamside protection). There are two groups:

General management requirements and mitigation measures apply to all methods.

Method-specific management requirements and mitigation measures pertain only to specific methods and are in addition to the general requirements and measures.

1. General Management Requirements and Mitigation Measures

The following general requirements and measures apply to all vegetation management methods. **Each forest may be more restrictive, but not less.**

a. Site-Specific Analysis

(1) Projects must have site-specific analysis in compliance with the National Environmental Policy Act (NEPA). This environmental analysis considers site-specific techniques, intensity of application methods, and potential environmental effects of any method considered. A reasonable range of alternatives, including one which does not use herbicides and a "no action" alternative, is examined.

Potential direct, indirect, and cumulative effects are evaluated. Effects to be considered include long-term soil productivity, water quality, air quality, visual quality, vegetation diversity, wildlife, fish, cultural resources, civil rights (including those of minorities and women), and threatened, endangered, proposed, and sensitive species.

The intent of this requirement is to ensure adequate environmental analysis. Congress and the Council on Environmental Quality have recognized the effectiveness of NEPA in developing environmental awareness and protecting the human environment. Monitoring is done through review of site-specific analyses and post-treatment evaluations.

(2) A biological evaluation of how a project may affect any species Federally listed as threatened, endangered, or proposed, or identified by the Forest Service as sensitive, is done as part of the site-specific environmental analysis. This evaluation considers all available inventories of threatened, endangered, proposed, and sensitive species populations and their habitat for the proposed treatment area. When adequate population inventory information is unavailable, it must be collected when the site has high potential for occupancy by a threatened, endangered, proposed, or sensitive species. Appendix D identifies potential adverse effects from vegetation management by species. When adverse effects are projected, mitigation measures specified in appendix D and this chapter are used to prevent them.

Requirements and measures for actions affecting threatened, endangered, or proposed species are detailed in species recovery plans and FSH 2609.23R. Recovery plans have been prepared for the red-cockaded woodpecker, southern bald eagle, gray bat, Indiana bat, eastern cougar, Florida panther, American peregrine falcon, American alligator, and the leopard darter. Chapters in FSH 2609.23R have been prepared for red-cockaded woodpecker, southern bald eagle, and American alligator. Requirements and measures for actions affecting sensitive species are detailed in Forest Land and Resource Management Plans.

If it is determined that the project may positively or negatively affect threatened, endangered, or proposed species, consultation is initiated with the Fish and Wildlife Service. If, during informal consultation, it is determined that the project is not likely to adversely affect listed species and the Fish and Wildlife Service so concurs in writing, consultation is terminated. However, if it is determined that the project is likely to adversely affect listed species, formal consultation is initiated. Figure D-1 outlines this process.

When the evaluation indicates that a project may have an adverse effect on a sensitive species or its habitat, appropriate State wildlife agencies, natural heritage commissions, and other cooperators or species authorities are contacted to identify coordination measures. These measures are directed towards ensuring species viability and preventing negative population trends that would result in Federal listing.

The intent of this requirement is to protect threatened, endangered, proposed, and sensitive species. Monitoring is done through review of site-specific analyses, onsite inspections, and post-treatment evaluations.

(3) Integrated Pest Management (IPM) principles are used during site-specific analysis. IPM is a decision-making and action process which includes biological, economic, and environmental evaluation of pest-host systems to manage pest populations.

IPM strategies apply a comprehensive systems approach to silvicultural, wildlife, range, fuel treatment, and corridor management practices that emphasizes prevention of pest problems. These strategies consist of a range of practices that include prescribed fire, manual, mechanical, biological, and chemical tools that may be used alone or in combination. Risk rating systems and pest incidence surveys are used during site-specific analysis. Further IPM direction is provided in FSM 3400, FSH 3409.11, and Forest Land and Resource Management Plans.

The intent of this requirement is to ensure use of IPM during project planning. Monitoring is done through review of site-specific analyses, onsite inspections, and post-treatment evaluations.

(4) In each project, water quality is protected from nonpoint-source pollution through use of preventive "best management practices" (BMP's). Implementation of BMP's, monitoring and evaluation of their application and effectiveness, and adjustment of practices as needed are done to protect beneficial water uses.

BMP's are applied to all activities in all alternatives. Some BMP's required to protect water quality appear in this section as mitigation measures for soil and water. BMP's applied in projects may be more stringent and more effective in protecting water quality than those in this section, but not less. In each project, site-specific conditions must be assessed, and the BMP's needed to comply with State water quality management plans and pertinent Federal regulations must be employed.

The intent of this requirement is to protect water quality and assure compliance with State water quality laws. Monitoring is provided through evaluation of BMP application and analysis of water quality.

b. Timber Stand Improvement (TSI)

(5) For evenage timber management, methods that maintain stocking levels (stems per acre) and improve growth rates are used (table II-1).

Table II-1.--*Southern Region restocking standards: number of desirable stems per acre.

Forest Type	Lower** Level	Target Level	Upper Level
Loblolly pine	150	500-700	900
Shortleaf pine	150	500-700	900
Mixed pine-hardwood	150	400-600	900
Hardwoods (all species)	150	250-350	500

* Stocking levels shown are guides, and must be used in conjunction with professional judgment to determine restocking levels for a specific site.

**Based on site index 50. See the Ozark-St. Francis and Ouachita Plans for Lower Level guides on sites where site index is greater than 50.

(6) Pine stands receive release and weeding necessary to meet growth rates and stocking levels established in Forest Land and Resource Management Plans. Stands are considered for release when the desired seedlings are not free to grow, when competing growth threatens to overtop and compete directly for sunlight, moisture, and nutrients, or when competition results in less-than-average growth for comparable sites.

(7) Precommercial thinning of pine (usually done before age 10 to 15 years) is considered when stem density exceeds the upper level of restocking standards.

(8) Hardwood stands are generally not released. Clumps of competing stems are removed, however, where they may interfere with desired trees.

(9) Hardwood stands, where codominant trees of seedling (not sprout) origin are 25 feet or taller, are considered for precommercial thinning.

(10) Where a mixed pine/hardwood type is the management objective, release or precommercial thinning will be designed to favor the best quality stems regardless of species.

The purpose of requirements (5) through (10) is to achieve species compositions and stand structures that reflect healthy, productive stand conditions. Knowledge gained through research and many years of management experience and contained in silvicultural guides have shown these measures to be effective. Monitoring is accomplished through periodic inventories.

c. Soil, Water, and Aquatic Life

(11) Channel stability of perennial and intermittent streams is protected by retaining all woody understory vegetation within at least 5 feet of the bank and by keeping slash accumulations out of the stream.

This measure is in addition to filter strips required on pages II-48 and II-52. It protects streams from excess channel erosion by preventing channel obstructions and maintaining living root systems on banks. Beasley (1979), Patric (1976), and Ursic (1975) show its importance in controlling channel erosion. Monitoring is accomplished through project plan reviews and onsite inspections.

d. Cultural Resources

(12) When soil disturbing activities are planned, an archaeologist performs a field survey to locate cultural resource sites and assess their significance and protection needs. Sites meeting criteria for significance are nominated to the National Register of Historic Places. All archaeological reports (surveys, site evaluations, site nominations, site protection measures) are submitted to the State Historic Preservation Officer for review.

(13) If archeological or historic resources are encountered during soil disturbing activities, work stops until an archeologist evaluates the site's significance and the results and recommendations are reviewed by the State Historic Preservation Officer.

The intent of measures (12) and (13) is to identify and preserve significant cultural resources. They ensure compliance with Federal and State laws protecting cultural resources. Monitoring is done through onsite inspections and post-project evaluations.

e. Safety

(14) Safety equipment for Forest Service workers (such as hard hats, eye and ear protection, chaps, and fire retardant clothes) is worn as determined by a Job Hazard Analysis specified in the Health and Safety Code Handbook (FSH 6709.11). This analysis estimates risks to specific body parts and prescribes needed protection.

The purpose of this measure is to reduce the number and severity of accidents. Experience and analysis of past accidents allow for effective measures to prevent future occurrences. Monitoring is done through onsite inspections and reviews of accident reports.

f. Visual Quality

(15) Visual Quality Objectives (VQO's) are met by corridor maintenance, site preparation, timber stand and wildlife habitat improvement, range forage, and fuels treatment projects. These VQO's are:

Preservation allows only for change not caused by humans. Generally, no treatments are permitted.

Retention ensures that human activities are not evident to the casual forest visitor. Concern for visual quality is primary. Visual impacts should be eliminated during or promptly after treatment. Many treatments are allowed, but raking, piling, disking, and broadcast herbicide methods are usually not appropriate.

Partial Retention means that human activities may be evident but remain subordinate to the characteristic landscape. Concern for visual quality is high. Visual impacts should be eliminated at a minimum within the first year. Most treatments are allowed, but disking and broadcast herbicides are limited. In corridors, all methods and tools are available.

Modification indicates that human activity may dominate the characteristic landscape. Treatments should borrow established line, form, color, and texture so completely that visual characteristics are compatible with natural surroundings. All methods and tools are available for use.

Maximum Modification means that human activity may dominate the landscape, but should appear as a natural occurrence when viewed as background. All methods and tools are used, and at a greater intensity than in modification VQO.

(16) Treatments are scheduled as much as possible for the season that best meets VQO's. Rehabilitation and enhancement work may be needed to meet short-term VQO's. Visual diversity along active travelways (such as canopy layering, flowering trees) is protected from treatments where feasible and needed to meet VQO's. Tool selection and coordination requirements are determined by a site-specific project analysis.

Measures (15) and (16) ensure consideration of visual quality objectives established in Forest Land and Resource Management Plans. Experience shows that meeting established visual quality objectives is effective in protecting the visual resource. Monitoring is done through onsite inspections and post-treatment evaluations.

g. Wildlife

(17) Wildlife stand improvement (WSI) seeks to improve vegetation species composition in timber stands and to develop wildlife habitat areas for game and nongame species. A variety of woody and herbaceous species suited to site conditions and burning regime are maintained to assure year-round quality habitat. Exceptions that may reduce plant species variety include treatments to improve habitat for species such as red-cockaded woodpeckers.

(18) For understory species WSI, proper management allows full sunlight on 30 percent of the forest floor. For hardwood overstory WSI, thinning encourages full crown development, vigorous growth, and soft or hard mast production. When thinning stands older than 30 years, stems are favored which show positive indication of bearing soft or hard mast.

(19) During TSI, WSI, and site preparation, selected groups of overstory and understory vegetation are protected and managed to assure a variety of soft-mast, hard-mast, and cover species. During site preparation, active and potential den trees are retained in clumps (at least 1/2 acre per 20 acres) if they are not provided in adjacent stands not suitable for timber production, inclusions, or streamside management zones. During TSI and WSI, all recognized den trees are protected. In addition, during TSI, WSI, and site preparation, an average of at least 2 standing dead snags are retained per acre, in the form of large hardwood trees (greater than 12 inches) when possible. Appropriate treatments are used to create snags where natural snags are lacking.

The intent of measures (17) through (19) is to provide a variety of wildlife and suitable habitat. Effectiveness is based on principles of wildlife management and habitat requirements as described in FSH 2609.23R, FSH 2609.13, and general wildlife management texts such as Peek (1986). Monitoring is accomplished through review of project proposals, onsite inspections, and periodic inventories.

h. Corridors

(20) Each forest works with utility special-use permittees to establish vegetation management objectives (such as wildlife, watershed, recreation, visual quality) for location of new utility lines and maintenance of existing ones. These objectives determine maintenance techniques and strategies.

(21) Where feasible, low-growing shrubs and grasses are established and maintained along utility lines where wildlife and aesthetic objectives are dominant. This measure applies only to alternatives B, D, E, F, and G.

(22) Where feasible, permanent vegetation is established and maintained on the roadbed of intermittent service roads when they are closed, and on the cut and fill slopes of all roads.

(23) Where practical, native flowering species are established, maintained, and enhanced on intermittent service roads when they are closed and on cut and fill slopes of all roads. This measure applies only to alternatives B, D, E, F, and G.

(24) Vegetation along trails is treated to maintenance levels identified in the publication "Trails South." Priority is given to correcting unsafe conditions, preventing resource damage, and providing for intended recreation experience level.

Measures (20) through (24) balance considerations for special uses and other forest values, promote safe and efficient use of facilities and limit adverse visual and erosion effects. Experience shows that careful coordination between resources and special uses effectively allows compatible, concurrent use. Monitoring is done through project proposal reviews, periodic inspections, and maintenance plan reviews.

i. Range Forage

(25) When managing for range forage species, wildlife and livestock use should not exceed 50 percent of current annual growth of key grass species, 20 percent of total annual production of key forb species, and 20 percent of current annual growth of key shrub species.

This requirement protects range forage from overuse and decline. Years of management experience and field inventories of range species have determined optimum use levels. Monitoring is done through allotment management reviews and periodic inventories.

j. Review and Reporting Requirements

(26) Each national forest must include vegetation management in its management review process. At a minimum, reviews must evaluate adequancy of vegetation management mitigations and monitoring.

(27) Using existing reporting systems, each national forest must report implementation of its vegetation management program annually. Every 3 to 5 years, Regional Office staff must assess these reports to be sure that the vegetation management program in the Ozark/Ouachita area approximates the acre distribution of methods and tools estimated for the selected alternative.

2. Method-Specific Management Requirements and Mitigation Measures

These requirements and measures are in addition to general requirements and measures in the preceding section.

a. Prescribed Fire

The following apply to alternatives that use prescribed fire. **Each forest may be more restrictive but not less.**

(1) A written site-specific plan for all prescribed burns is prepared by trained resource specialists and approved by the appropriate Forest Service line officer prior to project implementation. This plan includes description of treatment area, burn objectives, weather factors and fuel moisture

conditions, and resource coordination requirements. Coordination requirements include provisions for public and worker safety, burn day notification of appropriate agencies and persons, smoke management to comply with air quality regulations and protect visibility in smoke-sensitive areas, protection of visual and sensitive features, as well as fireline placement, specific firing patterns, ignition methods, and mop-up and patrol procedures. A post-burn evaluation compares treatment results with plan objectives.

This requirement ensures thorough planning, well-defined objectives, and selection of appropriate mitigation measures. Experience shows that planning and evaluation effectively eliminate avoidable adverse effects. Monitoirng is done through review of burn plans, onsite inspections, and post-burn evaluations.

Vegetation Protection

(2) Underburns in loblolly and shortleaf pine stands are not done until pines are 10 to 15 feet tall or 3 to 4 inches in diameter at ground level.

(3) Underburns are not done in commercial pine-hardwood stands and inclusions until hardwood stems reach 5 to 6 inches in diameter at ground level. Only low intensity, dormant season fires with flame lengths of 2 feet or less are allowed.

(4) Underburns are not done in commercial hardwood-pine or hardwood stands and inclusions until hardwood stems reach 8 to 10 inches in diameter at ground level. Only low intensity, dormant season backing fires with flame lengths of 2 feet or less are allowed. Underburns to improve wildlife habitat occur only if habitat is limiting and threatens species viability.

These measures protect trees from damage by fire. Chen, Hodgkins, and Watson (1975), Goebel, Brender, and Cooper (1967), Johnson (1982), Komarek (1974), and Wade (1986) show their effectiveness in limiting injury and mortality. Effectiveness is also based on principles of wildife management and habitat requirements as described in FSH 2609.23R 1980, FSH 2609.13, and general wildlife management texts such as Peek (1986). Monitoring is done in project proposal reviews and in post-burn evaluations.

Soil and Water Protection

(5) Slash burns are done so they do not consume all litter and duff and alter structure and color of mineral soil on more than 20 percent of the area. Steps taken to limit soil heating include use of backing fires on steep slopes, scattering slash piles, and burning heavy fuel pockets separately. This measure applies only to alternatives B, D, E, F, and G.

(6) On severely eroded forest soils, any area with an average litter-duff depth of less than 1/2 inch is not burned. This measure applies only to alternatives B, D, E, F, and G.

(7) Growing season underburns are not allowed on the same site more than twice in succession without an intervening dormant season burn. This measure applies only to alternatives B, D, E, F, and G.

Measures (5) through (7) protect soil productivity. Appendix B and the analysis in chapter IV found these measures effective in preventing excessive losses of soil biota, organic matter, and nutrients. Monitoring includes project proposal reviews and post-burn evaluations.

(8) Where needed to prevent erosion, water diversions are installed on firelines during their construction, and the firelines are revegetated promptly after the burn.

(9) Firelines which expose mineral soil are not located in filter strips along lakes, perennial or intermittent springs and streams, wetlands, or water-source seeps, unless tying into lakes, streams, or wetlands as firebreaks at designated points with minimal soil disturbance. Low-intensity fires with less than 2-foot flame lengths may be allowed to back into the strip along water bodies, as long as they do not kill trees and shrubs that shade the stream. The strip's width in feet is at least 30 plus 1.5 times the percent slope.

Measures (8) and (9) limit erosion and siltation. Cushwa, Hopkins, and McGinnes (1971) found that prevention of fireline erosion effectively eliminates sedimentation from many burns. Swift (1986) showed the above filter strip to be effective in trapping soil eroded by unconcentrated surface runoff. Monitoring is done in project proposal reviews, during burns, and in post-burn evaluations.

Wetland Protection

(10) When wetlands need to be protected from fire, firelines are used around them only when the water table is so low that the prescribed fire might otherwise damage wetland vegetation or organic matter. When practical, previous firelines are reused, and firelines must cause minimal soil disturbance.

(11) If a fireline is required next to a wetland, it is not located in the transition zone between upland and wetland vegetation except to tie into a natural firebreak, and it must cause as little soil disturbance as practicable.

The purpose of measures (10) and (11) is to prevent fireline scars which are often slow to heal in wetlands. Additionally, integrity of water flow in wetlands is protected. Monitoring is accomplished through project proposal reviews and post-burn evaluations.

Air Quality Protection

(12) Smoke management guidelines are used to reduce smoke emissions. When feasible, backing and flanking fires are used instead of heading fires, and burning is done when duff and large fuels are moist and small fuels are dry. Slash piles are not burned unless relatively free of soil. All burns are completed during the active burning period and mopped up as soon as practical after completion.

(13) Smoke management guidelines are also used to enhance smoke dispersion. Burning is done when the atmosphere is thermally neutral to slightly unstable, not during pollution alerts, stagnant or humid weather, or inversions. Burning is done only when:

-- air quality or visibility standards in smoke-sensitive areas (see "A Guide for Prescribed Fire in Southern Forests" (Wade and Lunsford 1989) pages 31-32) such as highways, airports, populated areas, and Class I areas will not be violated by smoke from the fire.

-- atmospheric mixing height is at least 1,650 feet, transport windspeed is at least 9 mph, and background visibility downwind is at least 5 miles.

The intent of these measures is to comply with air quality regulations and protect health and safety. Sandburg and Ward (1981), USDA Forest Service (1976), and Wade and Lunsford (1989) showed that such measures are effective in limiting smoke emissions and effects. Monitoring includes project plan reviews, pre-burn weather evaluations, and during-burn inspections.

Wildlife and Habitat Protection

(14) Oak-hickory, oak-pine, and oak-gum-cypress inclusions are protected by excluding fire or by using low-intensity backing fires.

(15) Generally, underburns are not scheduled during the nesting season to avoid disrupting reproductive activities. Forest managers may, however, use burns to meet specific objectives, such as protecting threatened and endangered species (e.g., red-cockaded woodpecker), reestablishing natural ecosystems, and site preparation. Burns are planned and executed to avoid damage to habitat of any threatened, endangered, proposed, or sensitive species (such as caves used as maternity and hibernating sites by the gray bat and Indiana bat, nests of Bachman's sparrow, and essential habitat of the Caddo Mountain, Fourche Mountain, and Rich Mountain salamanders).

(16) Underburns are planned to achieve their most desirable distribution for wildlife habitat and to try to break up large, continuous fuel types. When consistent with burning objectives, such burns are done to create a mosaic pattern of fuel types that complements fuel treatment and wildlife objectives. This measure applies only to alternatives B, D, E, F, and G.

Measures (14) through (16) protect valued habitats, minimize disruption of reproduction, and promote habitat variety. Effectiveness is based on principles of wildlife management and habitat requirements as described in FSH 2609.23R, FSH 2609.13, and general wildlife management texts such as Peek (1986). Monitoring occurs in project plan reviews and post-burn evaluations.

Safety

(17) Prescribed fires are conducted under the direct supervision of a burning boss with fire behavior expertise consistent with the project's complexity. All workers must meet health, physical and training requirements in FSM 5140, and use protective clothing and equipment.

This measure protects worker and public safety during prescribed burning. Monitoring occurs in project proposal reviews, onsite inspections, and post-burn evaluations.

General Resource Protection

(18) Critical values of the Keetch-Byram Drought Code (Cumulative Severity Index) are developed for all major vegetation-soil-landform types on which prescribed fires are conducted. Burning is allowed only on days when the Drought Code is less than this critical value.

This measure protects vegetation and soil from damage caused by burning during times of moisture deficiency. The Drought Code reflects the soil moisture deficit and potential fire severity. Experience has shown this measure to protect resources when used with other mitigation measures listed in this section. Monitoring is done in project proposal reviews, during burns, and in post-burn evaluations.

b. Mechanical Method

The following apply to alternatives that use mechanical methods. **Each forest may be more restrictive but not less.**

Soil and Water Protection

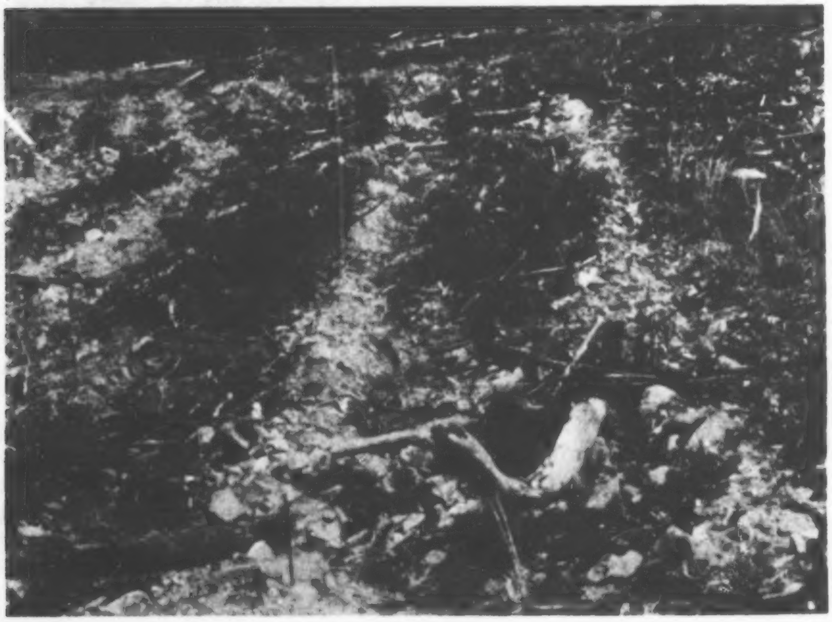
(1) Prompt revegetation is done if treatments leave insufficient ground cover to control erosion by the end of the first growing season.

(2) Only mowing, chopping, shearing, ripping, and scarifying are used on sustained slopes over 15 percent. No mechanical equipment is used on sustained slopes over 35 percent.

(3) Mechanical site preparation is not done on sustained slopes over 20 percent with erodible or failure-prone soils.

(4) To limit soil compaction, no mechanical equipment is used on plastic soils when the water table is within 12 inches of the surface, or when soil moisture exceeds the plastic limit. Soil moisture exceeds the plastic limit if the soil can be rolled to pencil size without breaking or crumbling.

(5) Mechanical equipment is operated so that furrows and soil indentations are aligned on the contour (with grades under 5 percent).



(6) Windrows and piles are spaced no more than 200 feet apart to limit soil exposure, soil compaction, and nutrient loss from piling and raking. Windrows are aligned on the contour.

(7) When piling, at least 80 percent of the area must retain some ground cover of litter and duff, and soil must not be displaced by piling rakes.

(8) Mechanical equipment is not allowed in any defined stream channel except to cross at designated points, and may not expose more than 10 percent mineral soil in filter strips along lakes, perennial or intermittent springs and streams, wetlands, or water-source seeps. The strip's width in feet is at least 30 plus 1.5 times the percent slope. Soil and debris are not deposited in lakes, streams, wetlands, springs, or seeps.

Measures (1) through (8) minimize soil damage and sedimentation. Beasley, Granillo, and Zillmer (1986), Blackburn, Wood, and DeHaven (1986), Gent, Ballard, and Hassan (1983), Gent and others (1984), and Swift (1986) found these measures to be effective and necessary to control soil damage and loss. Monitoring is done in project plan reviews and post-project evaluations.

Corridors

(9) All trails, roads, ditches, and other improvements in the project area are kept free of logs, slash, and debris. Any road, trail, ditch, or other improvement damaged by operations is promptly repaired.

This measure protects improvements. Experience shows that preventive measures or prompt repair effectively minimizes damages. Monitoring is done in project plan reviews and post-project evaluations.

Safety

(10) Forest Service equipment operators must demonstrate proficiency with the equipment and be licensed to operate it. A helper must direct the operator where safety is compromised by terrain or limited sight distance.

The intent of this measure is to protect worker and public safety. Monitoring occurs in periodic inspections and licensing.

c. Herbicide Method

The following apply to alternatives that use herbicides. **Each forest may be more restrictive but not less.**

(1) Herbicides are applied according to labeling information and the site-specific analysis done for projects. This labeling and analysis are used to choose the herbicide, rate, and application method for the site

conditions and species to be controlled. They are also used to select measures to protect human and wildlife health, non-target vegetation, water, soil, and threatened, endangered, proposed, and sensitive species. Site conditions may require stricter constraints than those on the label, but labeling standards are never relaxed.

Choice of Herbicide

(2) Only herbicide formulations (active and inert ingredients) and additives registered by EPA and approved by the Forest Service for use on National Forests are applied.

(3) Herbicides and application methods are chosen to minimize risk to human and wildlife health and the environment. Whenever possible and effective, class 4 or class 5 mineral oil is used in place of diesel oil in mixtures for application.

Application Rate

(4) Herbicides are applied at the lowest rate effective in meeting project objectives and according to guidelines for protecting human (NRC 1983) and wildlife health (EPA 1986a). Application rate and work time must not exceed typical levels (appendix A, tables 4-4 to 4-6) unless a supplementary risk assessment shows that proposed rates do not increase risk to human or wildlife health or the environment beyond standards discussed in Chapter IV. This measure applies only to alternatives B, E, F, and G. Typical application rates (lb/ac) of active ingredient are:

					FUEL				TRICLOPYR	
	FOSAM	GLYPH	HEXAZ	IMAZA	OIL	LIMON	PICLO	SULFO	Amine	Ester
AL	6.0	1.5	1.5	0.75	0.5	0.9	0.5	0.13	3.0	4.0
AG			1.7							
ML	7.8	1.5	1.7	0.75	2.0	0.9	0.7	0.17	4.0	4.0
MG			1.7							
HG			1.7							
HF		1.0	0.5	0.75	1.5	0.9	0.4	0.06	1.4	1.0
HB					1.0	0.9				1.9
HS			1.7							
HC		1.3		0.75			0.3		1.0	

KEY: AL = aerial liquid treatment
AG = aerial granular treatment
ML = mechanical liquid treatment
MG = mechanical granular treatment
HG = manual (hand) granular treatment
HF = manual foliar broadcast treatment
HB = manual basal stem treatment
HS = manual soil-spot treatment
HC = manual cut-surface treatment

GLYPHOS = glyphosate
HEXAZ = hexazinone
PICLO = picloram
SULFOMET = sulfometuron methyl
TEBUT - tebuthiuron
/a = amine formulation
/e = ester formulation

Application Method

(5) Method and timing of application are chosen to achieve project objectives while minimizing effects on non-target vegetation and other environmental elements. Selective treatment is preferred over broadcast treatment. Public safety during such uses as viewing, hiking, berry picking, and fuelwood gathering is a priority concern. This measure applies only to alternatives B, E, F, and G. Application methods from most to least selective are:

1) Cut surface treatments
2) Basal stem treatments
3) Directed foliar treatments
4) Soil spot (spot around) treatments
5) Soil spot (spot grid) treatments
6) Manual granular treatments
7) Manual/mechanical broadcast treatments
8) Helicopter treatments

Prescribed Burning of Treated Areas

(6) Areas are not prescribed burned for at least 30 days after herbicide treatment. This measure applies only to alternatives B, E, F. and G.

Measures (1) through (6) ensure legal compliance and mandate further steps to improve safety and effectiveness of treatment. The Risk Assessment (appendix A) shows that screening herbicides, reducing application rates, and using selective application methods lowers health and environmental risk. Experience has shown 30 days to be the minimum time for herbicides to work and fuels to cure. Monitoring is done by reviewing purchase orders, contract specifications, project reports, and annual herbicide-use reports.

Drift Control

(7) Weather is monitored and the project is suspended if temperature, humidity, or wind become unfavorable as follows:

	Temperatures Higher Than	Humidity Less Than	Wind Gusts (at Target) Greater Than
Ground:			
Hand (cut surface)	N.A.	N.A.	N.A.
Hand (other)	98F	20%	15 mph
Mechanical (liquid)	95F	30%	10 mph
Mechanical (granular)	N.A.	N.A.	10 mph
Aerial: Liquid	90F	50%	5 mph
Granular	N.A.	N.A.	8 mph

(8) Nozzles that produce large droplets or streams of herbicide are used. Nozzles that produce fine droplets are used only for hand treatment where distance from nozzle to target does not exceed 8 feet.

Measures (7) and (8) reduce drift of herbicides offsite. Yates, Akisson, and Bayer (1978) demonstrated their effectiveness. Monitoring occurs via weather observation and supervision.

Supervision and Training

(9) A certified pesticide applicator supervises each Forest Service application crew and trains crew members in personal safety, proper handling and application of herbicides, and proper disposal of empty containers.

(10) Each Contracting Officer's Representative (COR), who must ensure compliance on contracted herbicide projects, is a certified pesticide applicator. Contract inspectors are trained in herbicide use, handling, and application.

Measures (9) and (10) promote compliance with labeling instructions and reduce risk of accidents. Effectiveness and monitoring are provided by the Pesticide Applicators Training and Certification program, where a minimum test score of 70 percent is required for certification.

Protection of Workers

(11) Forest Service workers who handle herbicides must wear a long-sleeved shirt and long pants made of tightly woven cloth that must be cleaned daily. They must wear a hard hat with plastic liner, waterproofed boots and gloves and other safety clothing and equipment required by labeling. They must bring a change of clothes to the field in case their clothes become contaminated.

(12) Each Forest Service crew must take soap, wash water separate from drinking water, eyewash bottles, and first aid equipment to the field.

(13) Contractors ensure that their workers use proper protective clothing and safety equipment required by labeling for the herbicide and application method. This measure applies only to alternatives B, E, F, and G.

(14) Workers must not walk through areas treated by broadcast foliar methods on the day of application. This measure applies only to alternatives B, E, F, and G.

(15) Supervisors must ensure that monitoring is adequate to prevent adverse health effects. Workers displaying unusual sensitivity to the herbicide in use are medically evaluated and, if tested as sensitive to the herbicide in use, are reassigned to other activities.

Measures (11) through (15) reduce worker exposure to herbicides. Lavy, Mattice, and Norris (1984), Webster and Maibach (1985), and Yi-Lan and others (1984) demonstrate their effectiveness. Monitoring is done through supervision and review of accident reports.

Protection of the General Public and Private Land

(16) Notice signs (FSH 7109.11) are clearly posted, with special care taken in areas of anticipated visitor use. People living within one-fourth mile of an area to be treated aerially (alternatives G and H) are notified during project planning and shortly before treatment.

(17) No herbicide is broadcast within 100 feet of private land or 300 feet of a private residence, unless the landowner agrees to closer treatment. Buffers are clearly marked before treatment so applicators can easily see and avoid them. This measure applies only to alternatives B, E, F, and G.

(18) No herbicide is aerially applied within 200 horizontal feet of an open road or a designated trail. Buffers are clearly marked before treatment so applicators can easily see and avoid them. This measure applies only to alternatives G and H.

Measures (16) through (18) reduce public exposure to herbicides. Monitoring occurs during project plan reviews, onsite inspections, and post-project evaluations.

Protection of Non-Target Vegetation

(19) No soil-active herbicide is applied within 30 feet of the drip line of non-target vegetation (e.g., den trees, hardwood inclusions, adjacent stands) within or next to the treated area. Side pruning is allowed, but movement of herbicide to the root systems of non-target plants must be avoided. Buffers are clearly marked before treatment so applicators can easily see and avoid them. This measure applies only to alternatives B, E, F, and G.

This measure protects non-target plants in and next to treated areas. Appendices A and C show that buffers sharply reduce offsite movement. Monitoring occurs through project plan reviews, onsite inspections, and post-project evaluations.

Protection of Threatened, Endangered, Proposed, and Sensitive Species

(20) Triclopyr is not aerially applied (alternatives G and H) within 300 feet, nor ground-applied within 60 feet, of occupied gray or Indiana bat habitat. The same buffers are used with any formulation containing kerosene or diesel oil around habitat of any threatened, endangered, proposed, or sensitive bird during its nesting season. Buffers are clearly marked before treatment so applicators can easily see and avoid them.

(21) No herbicide is aerially applied (alternatives G and H) within 300 feet, nor ground-applied within 60 feet, of any threatened, endangered, proposed, or sensitive plant. Buffers are clearly marked before treatment so applicators can easily see and avoid them.

Measures (20) and (21) protect these species from toxic effects as predicted by the Risk Assessment (appendix A). They are consistent with EPA's proposed restrictions on use of certain herbicides. If EPA requires stricter standards for any herbicide in the future, the Forest Service will adopt them. Monitoring occurs through project plan reviews, onsite inspections, and post-project evaluations.

Protection of Water and Soil

(22) Application equipment, empty herbicide containers, clothes worn during treatment, and skin are not cleaned in open water or wells. Mixing and cleaning water must come from a public water supply and be transported in separate labeled containers.

(23) Aquifers and public water sources are identified and protected. States are consulted to ensure compliance with their ground water protection strategies.

(24) No herbicide is broadcast on rock outcrops or sinkholes. No herbicide with a half-life longer than 3 months is applied on slopes over 45 percent, erodible soils, or aquifer recharge zones. Such areas are clearly marked before treatment so applicators can easily see and avoid them.

(25) No herbicide is aerially applied (alternatives G and H) within 200 horizontal feet, nor ground-applied within 30 horizontal feet, of lakes, wetlands, or perennial or intermittent springs and streams. No herbicide is applied within 100 horizontal feet of any public or domestic water source. Selective treatments (which require added site-specific analysis and use of aquatic-labeled

best copy available

herbicides) may occur within these buffers only to prevent significant environmental damage such as noxious weed infestations. Buffers are clearly marked before treatment so applicators can easily see and avoid them.

Measures (22) through (25) reduce risk of surface and ground water pollution and soil erosion. Appendices A and C show that buffers sharply reduce offsite herbicide movement. Monitoring is done through project plan reviews, onsite inspections, and post-project evaluations.

Aerial Application Operations Plan

(26) Each aerial herbicide application project must have an operations plan approved by the forest's air safety officer who must ensure that: (a) adequate precautions are taken to protect the crew, including equipment certification and hazard identification; (b) areas to be aerially treated are clearly marked; and (c) methods used to avoid buffers and other sensitive areas are safe and effective. This measure applies only to alternatives G and H. .

This measure provides for crew safety and protection of non-target areas. Monitoring occurs through project plan reviews, onsite inspections, and post-project evaluations.

Control of Spills

(27) During transport, herbicides, additives, and application equipment are secured to prevent tipping or excess jarring and are carried in a part of the vehicle totally isolated from people, food, clothing, and livestock feed.

(28) Only the amount of herbicide needed for the day's use is brought to the site. At day's end, all leftover herbicide is returned to storage.

(29) Herbicide mixing, loading, or cleaning areas in the field are not located within 200 feet of private land, open water or wells, or other sensitive areas.

(30) During use, equipment to store, transport, mix, or apply herbicides is inspected daily for leaks.

(31) Containers are reused only for their designated purpose. Empty herbicide containers are disposed of according to 40 CFR 165.9 Group I & II Containers.

(32) Accident preplanning is done in each site-specific analysis. Emergency spill plans (FSM 2109.12, chapter 30) are prepared. In the unlikely event of a spill, the spill is quickly contained and cleaned up, and appropriate agencies and persons are promptly notified.

Measures (27) through (32) reduce risk of accidental contamination of humans or the environment by concentrated amounts of herbicide. Experience has shown them to be effective in reducing spillage and contamination. Monitoring occurs through supervision and incident report reviews.

d. Biological Method

The following apply to alternatives that use grazing as a biological method for pine release. **Each forest may be more restrictive but not less.**

(1) A site-specific analysis determines how livestock are managed to limit soil compaction, water contamination, and damage to riparian vegetation and streambanks.

(2) To protect seedlings, grazing as a biological method is excluded from:

(a) pine stands less than age 3 years; and

(b) hardwood stands for at least 5 years after stand establishment.

(3) Trampling damage or browsing of the terminal leaders of desired trees should not exceed 5 percent.

Measures (1) through (3) protect site values such as soil, water, and desirable vegetation when grazing is used as a biological control. Blackburn (1984) and Patric and Helvey (1986) showed that such controls reduce grazing damage to soil and water. Monitoring is done through project plan reviews and periodic on-site evaluations.

e. Manual Method

The following applies to alternatives that use manual methods. **Each forest may be more restrictive but not less.**

Safety

(1) Forest Service chain saw operators must be periodically certified and demonstrate proficiency with chain saws.

(2) Forest Service workers must comply with dress and safety standards specified in the Health and Safety Code Handbook (FSH 6709.11).

The intent of measures (1) and (2) is to protect worker and public safety. Monitoring occurs in periodic inspections and recertification.

F. COMPARISON OF ALTERNATIVES WITH THE ISSUES

Issues (chapter I) represent expressions of concern by the public and Forest Service employees, including management. These issues are the foundation for alternatives discussed earlier in this chapter. In this section, we compare the alternatives to see how they respond to the issues (table II-2).

Table II-2.--Comparison of alternatives with issues

ALTERNATIVE	ISSUES	
	Herbicides	Mechanical
Comparison Measure	Tool selectivity, risk, availability of aerial application.	Intensity
A (No Action)	No herbicides are available. There is no risk, and aerial application is not an issue.	No mechanical treatments are allowed, so there are no direct effects.
B	Acreage treated with herbicides is reduced from current (reduced risk). Treatments are highly selective. Aerial application is not available.	Only low intensity mechanical treatments are allowed (piling, disking, and raking are not available).
C (Current)	Treatments are mostly selective but broadcast (non-selective) treatments are available. All mitigations not required. Aerial application is not available.	Low to moderate intensity treatments are available.
D	Herbicides are not used.	Acres treated mechanically are increased from current by about 39 percent and only low to moderate intensity treatments are available.
E	Selective and non-selective treatments are available though selective treatments are emphasized. Risk is reduced from current levels by restricting application rates, reducing acres treated and requiring lower risk herbicides. Aerial is not allowed.	Acres treated mechanically are decreased from current by about 27 percent and only low to moderate intensity treatments are available (heavy disking and raking are not done).
F (Preferred)	Selective and non-selective treatments are available though selective treatments are emphasized. Risk is reduced from current levels by reducing exposure, reducing acres treated and selection of lower risk herbicides. Aerial is not allowed.	Acres treated mechanically are decreased from current by about 9 percent and only low to moderate intensity treatments are available (heavy disking and raking are not done).
G	About 10 percent more acres than current may be treated selectively or non-selectively; more non-selective treatments allowed in lieu of fire. Risks are reduced from current by reducing exposure and selection of lower risk herbicides. Aerial application is allowed on 600 acres of corridors and site preparation.	Acres treated mechanically are increased from current by about 15 percent and only low to moderate intensity treatments are available (heavy disking and raking are not done).
H	Selective and non-selective treatments are available and more non-selective treatments than curent are permitted. Acreage treated is about 46 percent larger. Risks are reduced through reducing exposure and use of lower risk herbicide (still higher than current). Aerial application is allowed on 14,500 acres of corridors, site preparation, and release.	Low to high intensity treatments are available (comparable to current) but slightly fewer acres are treated.

Table II-2.--Comparison of alternatives with issues

ALTERNATIVE	ISSUES		
	Balance of Resources	Prescribed Fire	Manual
Comparison Measure	Output mix, timber-related treatments.	Availability, timing, frequency, and intensity.	Availability, overall employment opportunity.
A (No Action)	Strongly favors outputs which occur without vegetation manipulation: Favors non-market. No treatments allowed for timber management.	Not available for use.	Not available for use. No vegetation management employment.
B	Favors non-market outputs. Market outputs are managed only to prevent resource damage. About 37 percent of vegetation management activities are for timber outputs.	Only about 64 percent of the current acres are treated. All burns are low-intensity and less frequent.	About 9 percent fewer acres treated. Employment less than half current levels.
C (Current)	Favors recreation (including wilderness), wildlife and timber (both market and non-market). About 40 percent of vegetation management activities are for timber outputs.	Low to high intensity burns are available and represent about 55 percent of the entire vegetation management program.	7,470 acres are currently treated manually. Overall employment opportunities are moderate.
D	Favors recreation (including wilderness), wildlife and timber (both market and non-market). About 40 percent of vegetation management activities are for timber outputs.	Acres treated increase by about 14 percent, frequency and timing are similar to current, however, only low to moderate intensity burnsare available.	About 3.1 times as many acres are treated (compared with current). Employment opportunities are only slightly higher, however, due to increased fire and mechanical.
E	Similar to current but some outputs may slightly decrease. Overall lower intensity treatments improve non-market outputs slightly. About 40 percent of vegetation management activities are for timber outputs.	About the same acres as current are treated. Only low to moderate intensity burns are available.	About the same as current for number of acres treated and employment opportunities.
F (Preferred)	Similar to current but some outputs may slightly decrease. Overall lower intensity treatments improve non-market outputs slightly. About 40 percent of vegetation management activities are for timber outputs.	About 4 percent more acres are treated, frequency and timing are similar to current, however only low to moderate intensity burns are available.	Acres treated are about 36 percent higher than current. Employment opportunities are little changed.
G	Favors recreation (including wilderness), wildlife and timber outputs both market and non-market). About 40 percent of vegetation management activities are for timber outputs.	About 2 percent fewer acres are treated, frequency and timing are similar to current, however only low to moderate intensity burns are available.	About 40 percent fewer acres are treated. Employment opportunities are slightly lower.
H	Favors market outputs, especially timber. About 37 percent (though about 6 percent more acres than current) of vegetation management activities are for timber outputs.	Low to high intensity burns are available. Frequency is less than current. Acres treated increase by 28 percent.	About 53 percent fewer acres are treated. Employment opportunities are highest of all alternatives.

Issues contain many values and are neither positive nor negative. Actually, issues express multiple concerns and desires, many of which are opposed to each other. Because of this aspect of issues, every alternative responds to each issue to some degree.

Major changes are expected when each alternative is compared with alternative A, the "no action" alternative (table II-2). Each issue is paraphrased in the following text, and the measure of comparison used in table II-2 is stated.

Herbicides: The principal concern is that non-target organisms, such as people, wildlife, or plants might be accidentally affected. There is also a fear of unknown long-term effects, particularly human health effects. Some people favor using herbicides and aerial application if adequate controls are maintained. Some also believe that aerial application is a necessity for treatment of corridors in steep inaccessible terrain. The measures of comparison are selectivity of treatment tools, level of risk, and availability of aerial application.

Mechanical: Many people feel that mechanical treatments should be used because they can produce an aesthetically pleasing effect. Some people suspect that mechanical treatments have significant effects on water quality, fisheries, soil productivity, and plant diversity. Comparisons are based on intensity of mechanical treatments.

Fire: Many people see prescribed fire as part of a "natural" system and as essential to provide for fuel reduction, wildlife habitat and diversity of plants and animals. Major concerns are about smoke management and potential adverse effects on soil, water, and visual quality. Comparison measures are availability of fire for fuel and habitat treatments and timing, frequency, and intensity.

Manual: People believe that manual treatments generate employment and have favorable effects on diversity, health and safety, and costs. Some recognize, however that while manual tools are more selective, they pose higher risks to employees and often cost more in the long term because treatment effects do not last. Comparison measures are availability of manual treatments and overall employment opportunity.

Balance of Resources: Concern is about the mix of resource outputs from national forests. It is believed that the principal use of vegetation management is for the benefit of timber. People also suspect that an increase in market outputs like timber or an increase in non-market outputs such as aesthetics would necessarily be at the expense of the other. The measures of comparison are changes in output mix and level of vegetation management activity devoted to timber.

G. COMPARISON OF ENVIRONMENTAL EFFECTS

Every alternative has the potential to cause environmental effects. Environmental effects are analyzed in chapter IV. Ways to limit or control these effects are the management requirements and mitigation measures discussed earlier in this chapter. Because each alternative represents a different way to accomplish vegetation management work, effects will also differ.

Makeup of Alternatives

Kinds of effects and their severity or seriousness are determined by several factors:

- Which methods and tools are used?
- How many acres are treated?
- What intensity and frequency of treatments are applied?

Before reading the evaluation of environmental effects in chapter IV or looking at the comparison of effects between alternatives in table II-7, readers should become familiar with how these factors vary between alternatives. If the factors are understood, then the type and severity of effect will be better understood.

Table II-3 displays methods and tools available for use in each alternative. Each alternative has a unique set of methods and tools. For example, herbicide methods are not available in alternative D, mechanical treatments are substantially reduced in alternative E, aerial herbicide application tools are available in varying rates only in alternatives G and H. Careful review will find many other differences.

Table II-4 shows the number of acres treated with each method in each alternative, and lists total acres treated. Total acres range from zero to 126,406. Table II-5 is just another way of expressing data in table II-4 in order to more clearly show how use of each method varies from alternative to alternative. In all alternatives where vegetation management is done, biological represents a small fraction of treatments. Use of other methods varies substantially between alternatives. For example, in alternative F about 24 percent of the total acres are treated with herbicides, while in alternative G 31 percent of the total acres are treated (table II-5). Tables II-4 and II-5 should be used together, however, because total acres treated by all methods vary. Note that in alternative

Table II-3.--Comparison of alternatives and tools

A (No Action)	B	C (Current)	D
None	Herbicides Hand ground tools Backpack sprayer Spotguns Hypo-hatchets Injectors Axe & sprayer	Herbicides Mechanical ground tools Boom sprayer Granular spreader Hand ground tools Backback sprayer Spotguns Hypo-hatchets Injectors Axe & sprayer	Herbicides None
None	Mechanical Low soil disturbance Mowing Chopping Shearing Ripping Scarifying	Mechanical Low to moderate soil disturbance Mowing Chopping Shearing Ripping Scarifying Piling Light Disking	Mechanical Low to moderate soil disturbance Mowing Chopping Shearing Ripping Scarifying Piling Light disking
None	Manual Power tools Hand tools	Manual Power tools Hand tools	Manual Power tools Hand tools
None	Fire Low intensity Dormant season burns Aerial tools Ground tools	Fire Low to high intensity Dormant and growing season burns Aerial tools Ground tools	Fire Low to moderate intensity Dormant and growing season burns Aerial tools Ground tools
None	Biological None	Biological None	Biological Livestock

Table II-3.--Comparison of alternatives and tools (continued)

E	F (Preferred)	G	H
Herbicides Mechanical ground tools Boom sprayer Granular spreader Hand ground tools Backpack sprayers Spotguns Hypo-hatchet Injectors Axe & sprayer	Herbicides Mechanical ground tools Boom sprayer Granular spreader Hand ground tools Backpack sprayer Spotguns Hypo-hatchets Injectors Axe & sprayer	Herbicides Aerial tools Helicopter Mechanical ground tools Boom sprayer Granular spreader Hand ground tools Backpack sprayers Spotguns Hypo-hatchets Injectors Axe & sprayer	Herbicides Aerial tools Helicopter Mechanical ground tools Boom sprayer Granular spreader Hand ground tools Backpack sprayers Spotguns Hypo-hatchets Injectors Axe & sprayer
Mechanical Low soil disturbance Mowing Chopping Shearing Ripping Scarifying	Mechanical Low to moderate soil disturbance Mowing Chopping Shearing Ripping Scarifying Piling Light disking	Mechanical Low to moderate soil disturbance Mowing Chopping Shearing Ripping Scarifying Piling Light disking	Mechanical Low to high soil disturbance Mowing Chopping Shearing Ripping Scarifying Piling Raking Light disking
Manual Power tools Hand tools	Manual Power tools Hand tools	Manual Power tools Hand tools	Manual Power tools Hand tools
Fire Low to moderate intensity Dormant and growing season burns Aerial tools Ground tools	Fire Low to moderate intensity Dormant and growing season burns Aerial tools Ground tools	Fire Low to moderate intensity Dormant and growing season burns Aerial tools Ground tools	Fire Low to high intensity Dormant and growing season burns Aerial tools Ground tools
Biological None	Biological None	Biological Livestock	Biological Livestock

Table II-4.--Comparison of acres treated by alternative

	Alternative							
Method	A	B	C	D	E	F	G	H
Herbicide	0	10,990	28,605	0	29,064	24,492	31,388	41,240
Mechanical	0	5,565	7,868	11,141	5,996	7,345	8,703	7,353
Fire	0	35,462	57,229	65,898	58,366	59,219	55,797	73,424
Manual	0	6,798	7,472	23,092	7,748	10,118	4,817	3,332
Biological	0	0	0	1,043	0	0	469	807
Total	0	58,815	101,174	101,174	101,174	101,174	101,174	126,156
% Treated**	0	2.2	3.7	3.7	3.7	3.7	3.7	4.7

**Portion of total 2.7 million acres treated on an annual basis.

Table II-5.--Comparison of method mix (% acres treated) within alternatives

	Alternative							
Method	A	B	C	D	E	F	G	H
Herbicide	0	18.7	28.3	0	28.7	24.2	31.0	32.7
Mechanical	0	9.5	7.8	11.0	5.9	7.3	8.6	5.8
Fire	0	60.3	56.5	65.2	57.7	58.5	55.1	58.2
Manual	0	11.5	7.4	22.8	7.7	10.0	4.8	2.7
Biological	0	0	0	1.0	0	0	0.5	0.6

Table II-6--Average treatment frequencies (years) by alternative

Treatment of	A	B	C,D,E,F,G	H
Hazardous Fuels	None	7	6	4
Threatened & Endangered Species Habitat	None	3	3	3
Other Wildlife Habitat	None	6	5	4
Trails	None	3	1	1
Roads-Forest Service	None	5	3	2
Roads-County/State	None	2	1	1
Power Lines	None	7	6	4
Gas Lines	None	3	2	1
Range Habitat	None	6	5	4

B, about 61 percent of the acres treated are done with prescribed fire, yet this is only 35,587 acres. Compare this with alternative H where a lower percentage of acres (57) are treated with prescribed fire, but number of acres treated is 72,250.

Table II-6 lists frequency of recurring treatments in each alternative. As with the other factors, significant variations exist.

Environmental Effects

Numerous known and estimated environmental effects are discussed in chapter IV which forms the scientific and analytic basis for the comparisons in this section (40 CFR Part 1502.16). Chapter IV discloses effects on each environmental element (such as soil, air, or human health). This section compares how all environmental elements are affected in each alternative. Chapter IV is technical and lengthy. This section summarizes information from chapter IV, and is less technical.

A comparison of the principal environmental effects for each alternative is presented in table II-7. Socioeconomic effects are shown in table II-8.

Effects on wildlife are measured as variety of habitats. While direct effects do occur, the indirect effect of alteration of habitat is the most important variable affecting wildlife. Habitat is described by successional stage. Where areas are not treated at all, they tend to progress toward later successional stages.

Evaluation of effects on threatened, endangered or sensitive species of plants and animals broadly considers whether or not it is possible to achieve recovery. Recovery is the primary objective of management activities for these species.

Human health effects are measured as risk to human health from use of herbicides, and risk of accidental injury from use of vegetation management tools. Indirect effects such as accidents related to wildfire occurrence and suppression are also stated.

Effects on vegetation are generally reflected as changes in species composition. Species composition is the kinds, numbers, and distribution of plants growing on a site. Table II-7 shows effects on woody and herbaceous vegetation and ranks alternatives based on their effects on woody vegetation. Generally, treatments (or lack of treatment) favoring woody vegetation will negatively affect herbaceous vegetation, and conversely.

Table II-7.--Comparison of environmental effects by alternative

		Affected Environmental Element			
		Human Health and Safety	Wildlife	Threatened, Endangered, Proposed, & Sensitive Species	Vegetation
	Comparison Measure(s)	Risk to human health, risk of injury.	Variety of habitats.	Plant and animal species recovery.	Understory species development. Adverse effects of woody species (ranking).
ALTERNATIVE	A (No Action)	No direct risks. Risks from wildfire are highest. Lowest overall risk.	Highly favors mid-late successional species. Early successional in natural disturbances and harvest areas only.	Habitat not managed, many species decline. Recovery not likely.	Woody under- and midstory highly favored. Intolerant hardwood and pine decline. Ranking = 1 (least effect)
	B	Herbicide risks are low; less than C. Risk of injury low for all other methods.	Favors mid-late successional species. Early successional habitat more available than A.	Recovery of known populations likely.	Woody under- and midstory favored. Herbaceous understory favored only on corridors, fuel tmt, T&E areas. Ranking = 2.
	C (Current)	Current level. Herbicide and mechanical risks low; manual moderate to high. Fire-related risk is high.	Mixed early-mid-late successional habitats. Use of high intensity fire and herbicides favor early successional species.	Recovery of known populations likely.	Woody under- and midstory reduced. Broadcast herbicides, low-high intensity fire, low-moderate disturbance mechanical favor herbaceous understory. Ranking = 6.
	D	No risk from herbicide but highest risk from manual methods. High fire, moderate mechanical, and low risk from biological.	Favors mid-late successional species, more than C due to more manual, less than E or F due to more fire-mechanical.	Recovery of known populations likely.	Woody under- and midstory increased. High use of manual, low-moderate intensity fire, low-moderate disturbance mechanical, favors woody understory. Ranking = 5.
	E	Mechanical risks reduced; biological no risk. All others same or slightly higher than at present.	Mixed early-mid-late successional habitats, but early stage is limited due to decreased mechanical.	Recovery of known populations likely.	Woody under- and midstory favored. Less mechanical and more manual favor woody understory. Ranking = 4.
	F (Preferred)	Herbicide risk less than current; accident risk higher for fire and manual, moderate for others.	Mixed early-mid-late successional habitats. Less early successional habitat than E, more than B.	Recovery of known populations likely.	Woody under- and midstory favored due to selective herbicides, low-moderate intensity fire and mechanical, increased manual. Ranking = 3.
	G	Herbicide and mechanical risk show slight increase from present; both still low risk. Fire and manual decline from present risk. Slight overall improvement.	Mixed early-mid-late successional habitats. Increased herbicide, including aerial, and increased mechanical favors early-mid successional species.	Recovery of known populations likely.	Woody under- and midstory reduced, more than C but less than H. Broadcast herbicides, including aerial, low-moderate mechanical, favors herbaceous understory. Ranking = 7.
	H	Highest risk of accidents from herbicides and fire. Manual methods also pose high risk. Mechanical and biological pose low risk. Highest risk of herbicide drift onto non-workers from aerial.	Highly favors early successional stage species.	Recovery of known populations likely.	Highest reduction of woody under- and midstory. Increased broadcast herbicides, mechanical disturbance, fire intensity highly favor herbaceous understory. Ranking = 8 (most effect)

Affected Environmental Element				
Soil	Water & Aquatics	Air	Visual Quality	Cultural Resources
Risk of long-term soil productivity loss.	**Tons of sediment, risk of herbicide pollution.**	**Acres burned. Tons of smoke produced annually.**	**Visibility of work. Meets VQO's.**	Risk of loss or damage.
Risk 2.7 times that of E, due to intense wildfires.	Wildfires produce some sediment. No risk of herbicide pollution.	Slash burns = 0, underburns = 0, Wildfires = 3,800 ac. producing 1,900 tons of smoke.	No work done. VQO's not met for vistas or other areas requiring manipulation.	Lowest - though wildfire may damage architectural resources.
Risk 1.8 times that of E, due to some intense wildfires.	Wildfires produce some sediment. Treatments produce 160 tons. Negligible risk of herbicide pollution.	Slash burns = 4,800 ac., underburns = 30,700 ac., wildfires = 2,400 ac. producing 6,700 tons of smoke.	Work less visible than present. VQO's will generally be met.	Low - wildfire may damage architectural resources.
Risk 130 times that of E, due to some severe slash burns.	Treatments produce 930 tons of sediment. Negligible risk of herbicide pollution.	Slash burns = 6,300 ac., underburns = 50,900 ac., wildfires = 1,000 ac. producing 9,000 tons of smoke.	High visibility, significant disruptions. VQO's will generally be met.	Moderate to high primarily from mechanical methods.
Risk 36 times that of E, due mostly to use of biological method.	Treatments produce 710 tons of sediment. No risk of herbicide pollution.	Slash burns = 14,600 ac., underburns = 51,300 ac., wildfires = 1,000 ac. producing 12,200 tons of smoke.	Higher visibility than C. VQO's will generally be met.	Highest. Most acres treated mechanically of all alternatives.
Lowest risk due to use of low to moderate disturbance tools.	Treatments produce 430 tons of sediment. Negligible risk of herbicide pollution.	Slash burns = 7,400 ac., underburns = 51,000 ac., wildfires = 1,000 ac. producing 9,500 tons of smoke.	Similar to C. VQO's will generally be met.	Very low. Due to limited use of mechanical tools.
Very low risk, 7% more than E, due to use of low to moderate disturbance tools.	Treatments produce 360 tons of sediment Negligible risk of herbicide pollution.	Slash burns = 7,900 ac., underburns = 51,300 ac., wildfires = 1,000 ac. producing 9,700 tons of smoke.	Lower overall visibilty. VQO's will generally be met.	Moderate. Slightly less acres treated than current.
Risk 16 times that of E, due to use of biological method.	Treatments produce 520 tons of sediment. Some risk of herbicide pollution.	Slash burns = 5,900 ac., underburns = 49,900 ac., wildfires = 1,000 ac. producing 8,800 tons of smoke.	Similar to C. VQO's will generally be met.	Higher than current because of more acres treated mechanically.
Highest risk, 250 times that of E, due to emphasis on high disturbance tools.	Treatments produce 1,720 tons of sediment. Most risk herbicide pollution.	Slashburns = 6,300 ac., underburns = 67,100 ac., wildfires = 1,000 ac. producing 9,900 tons of smoke.	Foreground and middleground strongly influenced by work. May not meet VQO's.	Slightly higher than current because of less restrictions on mechanical methods.

Table II-8.--Effects of alternatives on socioeconomics

Alternative	Total Cost	Cost/ Acre	Indirect Cost	Resource Outputs	User Expectations	Employment Opportunity
A No Action	N/A	N/A	Highest	Favors unmanaged	Favors primitive	Lowest
B	$ 1,878,000	$31.86	Much higher than current	Favors unmanaged	Favors semi-primitive	Much lower than current
C Current	3,499,000	34.47	Moderate	Allows both managed and unmanaged	Favors semi-primitive to rural	Moderate
D	2,900,000	28.87	High where herbicides are not used	Comparable to current	Favors semi-primitive to rural	Slightly higher than current
E	3,412,000	33.62	Higher than current	Comparable to current	Favors semi-primitive to rural	Moderate
F Preferred	3,364,000	33.14	Comparable to current	Comparable to current	Favors semi-primitive to rural	Comparable to current
G	3,572,000	35.37	Slightly higher than current	Comparable to current	Favors semi-primitive to rural	Slightly lower than current
H	4,222,000	33.64	Lower than current	Favors managed	Favors roaded natural/ rural	High

Alternatives are ranked according to their potential to cause long-term soil productivity losses. Risk of lost soil productivity is based on soil compaction and loss of organic matter, nitrogen, and soil organisms. Such effects may occur from use of prescribed fire, raking, piling, or biological methods. Effects vary depending on soil type. Alternatives are ranked by determining how much of each treatment is used, and on which soil types.

Two different effects on water and aquatic life are displayed in table II-7. Tons of sediment produced annually means the estimated sediment produced by vegetation management treatments which reaches streams despite mitigation measures. The other effect is the potential for herbicide pollution of streams.

Effects on air quality from vegetation management activities result mainly from smoke produced by prescribed fires. Some is also produced by wildfires, and in some alternatives, lack of vegetation management increases the acres burned by wildfire. Table II-7 displays the numbers of acres burned by all types of fires and lists the total tons of smoke produced annually.

Visibility of work and achievement of visual quality objectives are two measures of effects on visual quality. Whether or not vegetation management work can be seen by the average user depends largely upon how many acres are treated and where the work is located. An additional factor contributing to visibility is intensity of work. Vegetation management treatments often improve appearances of harvested sites. Visual quality objectives (VQO's) are goals for desired visual conditions which have been established for all landscapes.

An estimate of risk of damage or loss is used to state effects on cultural resources. Damage or loss is most likely to occur wherever the ground is disturbed. Some cultural resources may also be affected by fire. Generally, effects from ground disturbance increase with depth of penetration by the tool being used, and with soil displacement. Risks related to fire increase with increased wildfire occurrence, but generally not with increased use of prescribed fire.

Economic and Social Effects

Economic and social effects are in table II-8. Six types of effects are shown.

Total cost reflects the annual expenditure necessary to accomplish the vegetation management program. It is calculated by determining the cost of using each method for each activity proposed, and multiplying by the number of acres treated.

Cost per acre is actually an average cost determined by dividing total cost by total acres treated. Average costs are influenced by methods used for treatment, as some methods are more costly than others.

Indirect costs and opportunity costs are extremely difficult to quantify. It is also not always easy to determine who pays these costs. For example, if good silvicultural practices aren't used, sites won't produce wood products to their capability. This results in lower harvest volumes, thus lower receipts to the treasury. But, lower receipts result in lower payments to counties, which in turn often results in higher taxes to maintain services. Another example is that low or no maintenance of rights-of-way causes damage to facilities within them. For an electric transmission line, the utility company spends more for repairs, but these additional costs are passed on to consumers and shareholders. Also, in some situations, manual methods may be ineffective due to sprouting and require multiple treatments and substantially increased costs.

Resource Outputs are classed as managed or unmanaged. While most outputs such as wildlife, timber, recreation, and forage require some form of management, there are some like wilderness or late successional species which occur in the absence of vegetation manipulation.

User expectations cover a range from semi-primitive nonmotorized to rural settings. These settings are explained in chapter III. Generally, as more vegetation treatments are done, more expectations toward the rural end of the scale can be met.

Employment opportunity is stated qualitatively (low to high), and reflects only those jobs directly associated with vegetation management. Numbers of jobs available depend on the labor intensity of methods used, total dollar expenditures, and numbers of acres treated. Manual methods are the most labor intensive, but selective herbicide treatments also have a high labor component.

H. SUMMARY OF COMPARISON OF ALTERNATIVES

This section is a brief summary of the effects of the alternatives displayed in tables II-7 and II-8. For more detail, see section IV-M.

Alternative A **has** least risk of effects because no treatment **is done**. No herbicides are used so there is no risk of adverse **human health** effects or **water pollution** from them. Increased fuel loads raise the risk of more **wildfires** with greater intensity, increasing risk to persons and properties on adjacent lands. Mid- to late-successional **wildlife** species such as gray squirrel benefit from lack of treatment, while early successional species such as quail lose habitat. **Threatened, endangered, proposed, and sensitive species** have mixed effects: some species gain and others lose habitat with recovery unlikely. Woody **vegetation** thrives while herbaceous and shade-intolerant plants decline. **Soil productivity** may be impaired by severe wildfires. **Water and Air quality** are affected least in this alternative because of the lack of prescribed fire and other treatments. **Visual quality** is reduced because vegetation is allowed to encroach upon scenic views and vistas. Risk to **cultural resources** is low although damage could occur from wildfires. Because no funds are spent for vegetation management, **costs** are low in this alternative. **Output** of managed resources declines substantially. There is no **employment** provided by vegetation management.

Alternative B is restricted to treatments that achieve minimum resource objectives. Risk to **human health and safety** is minimized by limited herbicide use and a restricted program. Effects on **wildlife** are similar to those in alternative A, but fire-dependent species benefit more because nearly 22,000 acres are prescribed burned for wildlife and **T&E species**. Recovery of threatened, endangered, proposed, and sensitive species is likely if impacts from external factors are controlled. Selective application of herbicides and prescribed fire results in small losses of nontarget plants. **Herbaceous species** decrease in number, and a greater amount of **woody species** grow into the midstory and understory. Impairment of **soil productivity** is minimal. Because all treatment intensities are low, effects on **water and aquatics** from herbicides and sediments are negligible. Annual **smoke emissions** from wildfires and prescribed fires are estimated to be about 3.5 times those of alternative A. Work is much less **visible** than currently. Risk to **cultural resources** is lowest except for alternative A. Alternative B primarily benefits those who enjoy primitive forest settings. **Employment opportunities** are lowest of all the alternatives involving management activities. **Managed outputs** decline from present levels. Per acre and total **costs** are lowest of all alternatives using vegetation management.

Alternative C continues present levels of treatment specified in Forest Land and Resource Management Plans. **Human health** risk from herbicides is low for workers and the public. Risk of **injury** from manual methods is low to moderate while risk from fire-related **accidents** is high. A wide range of vegetation management tools provides a variety of habitats and successional stages for many **wildlife** species. Mitigation measures assure adequate recovery of **threatened, endangered, proposed, and sensitive species**, and recovery is likely if impacts from external factors are controlled. Broadcast treatment of herbicides, use of low to high intensity burns, and low to moderate disturbance mechanical tools increase **herbaceous species** and reduce **woody species**. Such treatments also increase risk of damage to nontarget plants. Over time, risk of **soil impairment** is moderate due to some use of severe slash burns, and overall risk to **water and aquatics** is low due to 820 tons of **sediment** produced per year. Effects on herbicide concentrations in water are minimal. Annual **smoke emissions** from prescribed fires and wildfires are estimated to be about 4.5 times those of alternative A. **Visual impacts** result mainly from prescribed fire, herbicide, and mechanical treatments, but degree of impairment is generally short-term. Use of ripping represents high potential for **cultural resource** damage. **Socioeconomic conditions** offer a balance for those who enjoy primitive or semi-primitive settings and for those who enjoy more developed forest settings. There is a high level of **employment opportunity**. Per acre **costs** are exceeded only by those in alternative G; total costs are higher than alternatives A, B, D, E, and F.

Alternative D does not use herbicides, so risk to **human health** and **water quality** from herbicides does not exist. Because other methods are used in place of herbicides, risk of accidental **injury** is very high. Early successional **wildlife** such as mourning dove are favored by use of mechanical methods and growing season burns. **Threatened, endangered, proposed, and sensitive species** can recover. Effects on woody **understory** are greater than alternatives A, B, E, and F. Herbaceous understory is favored by mechanical and prescribed fire use. Risk of lost **soil productivity** is about 40 times that of alternative E, due mostly to use of heavy grazing for pine release. **Sediment** produced is higher than in all other alternatives except C and H. The amount of **smoke** produced is more than any other alternative. **Visibility** of work is about the same as current, but browning caused by herbicides is absent. Visual quality objectives may be met. Risk of loss or damage to **cultural resources** is highest because more mechanical methods are used. Total program **cost** is lower than every alternative except A and B. Indirect costs are incurred whenever herbicides would have been more cost-effective. **Outputs**, managed and unmanaged, vary little from current levels. **Experiences** can be had in all settings, with more semi-primitive settings than current. More **employment** opportunities than currently available are offered.

Alternative E shifts away from use of mechanical treatments and decreases intensity of treatments. Risks to **human health** are comparable to current though there is a slight increase in risk of **accidents** from increased use of manual and prescribed fire methods. Less intensive treatments and fewer mechanical treatments favor mid-to-late successional **wildlife** habitat. **Threatened, endangered, proposed, and sensitive species** can recover. Effects on **woody understory** are less than alternatives H, G, D and C. Risk of **soil impairment** is lowest of all alternatives. **Water and aquatic** risk is in the low range but higher than alternatives A, B, and F, with 400 tons of **sediment** produced. **Smoke emissions** are nearly 4.8 times those in alternative A. **Visual quality** is similar to alternative C with VQO's generally met. Risks to **cultural resources** are very low, principally due to the reduction in mechanical treatments. User **experiences** are available in all settings. Per acre **costs** are almost exactly the same as alternative H, but total costs are slightly less than current, and indirect costs rise. **Employment opportunity** may be only slightly lower than current. The mix of resource **outputs** is little changed.

Alternative F provides for decreases in herbicide and mechanical treatments. Risks to **human health** are slightly decreased from current, but risk of **accidents** increases as use of manual and prescribed fire methods increases. Less intensive treatments and a reduction in mechanical treatments favors mid-to-late successional **wildlife** habitat. **Threatened, endangered, proposed, and sensitive species** are able to recover. Effects on **woody, under- and midstory** species are lower than all alternatives except A and B. Risk of **soil impairment** is very low, only slightly higher than alternative E. **Sediment** production is lower than any alernative other than A and B, and risks to **water and aquatic** species are negligible. **Smoke** production is equivalent to alternative E at about 4.8 times that of alternative A. **Visual quality** is similar to alternative C, with VQO's generally met, but work is somewhat less visible. Risks to **cultural resources** are lower than curent due to reduced use of mechanical. All forest settings exist to meet a variety of **user expectations**. Per acre and total **costs** are in the mid range, lower than alternative C, E, G, and H, but higher than B or D. Indirect costs are comparable to current. **Employment** opportunity is also not changed. Resource **outputs** should achieve current mixes.

Alternative G increases the use of herbicides and mechanical methods. Risks to **human health** are in the low range, just slightly higher than current. The small reduction in use of prescribed fire and manual reduces risks of **accidental injury**. Favored use of herbicides and mechanical allows a more lasting effect creating early successional **wildlife** habitat, though all stages are adequately provided. Recovery of **threatened, endangered, proposed, and sensitive species** is likely. Effects on **woody under- and midstory species** are more severe than all alternatives except H. Risks to **soil productivity** are 18 times as great as those in alternative E. **Sediment** production is 430 tons (less than alternatives C, D, or H), but the introduction of limited aerial application of herbicides presents some risk to **water and aquatic** life. **Smoke production** is lower than all alternatives other than A or B. **Visual quality** is comparable to current. Risks to **cultural resources** are higher than current due to increased reliance on mechancial treatments. Per acre **costs** are highest of all alternatives and total costs are exceeded only by those for alternative H. There is a slight increase in indirect costs from current due principally to the inefficient use of some treatments. **Outputs** retain their current mix. A variety of user **settings** exist. **Employment** is slightly **lower** than current.

Alternative H achieves maximum vegetation control. **Human health** risks are greatest in this alternative, though only slightly greater than alternative G. Risks of **accidental injury** are increased in the extensive use of prescribed fire, but are substantially reduced for manual treatments. Herbaceous species predominate, **woody under- and midstory species** are affected more than other alternatives. This alternative limits production of hard- and soft-mast used by many **wildlife** species. Recovery is likely for **threatened, endangered, proposed, and sensitive species** if impacts from external factors are controlled. Impacts on **soil productivity** and **water and aquatic** life are highest in this alternative due to emphasis on intensive treatments. Vegetation management work is highly **visible** and some VQO's may not be met. **Smoke emissions** are moderate, comparable to alternatives E or F. Potential impacts to **cultural resources** are slightly higher than current. Rural **experience settings** are more favored. **Employment** opportunities are high. **Outputs** may exceed Forest Plan levels. Total **costs** are highest, but per acre costs are in the mid range, slightly lower than current.

Aerial Application

Two alternatives include **aerial application of herbicides** by helicopter. This technique reduces worker exposure but increases potential for offsite drift and accidental water contamination due to overflight of streams. **Alternative G** aerially treats 600 acres per year. Most of these are for site preparation and some are for utility line maintenance. **Alternative H** expands use of aerial application to 14,500 acres per year. Most of these are for pine release, but some are for site preparation and utility lines. Mitigation measures including use of low-drift delivery systems and buffer strips along streams reduce risk of water contamination and offsite drift.

Aerial application of herbicides is currently suspended by the Chief of the Forest Service. If the Record of Decision includes aerial application, the Regional Forester will request the suspension be lifted prior to using aerial methods.

I. IDENTIFICATION OF PREFERRED ALTERNATIVE

Alternative F is the Forest Service's preferred alternative.

Affected Environment

CHAPTER III

CHAPTER III

AFFECTED ENVIRONMENT

IN BRIEF

Part A identifies the geographic area analyzed and describes its physiography and climate. Part B describes in more detail the facets of the environment that may be affected by proposed actions.

A. PHYSICAL AND BIOLOGICAL SETTING

This EIS covers the Ozark-St.Francis and Ouachita National Forests. These forests lie entirely in Arkansas, except for the Choctaw, Kiamichi and Tiak Ranger Districts of the Ouachita National Forest in southeastern Oklahoma. The forests contain 2.7 million acres and are managed by two Forest Supervisors.

1. Physiography

The South contains five physiographic divisions (figure III-1). This EIS covers the Interior Highlands and two small units in the Coastal Plain. The Interior Highlands division includes the Ozark Plateaus and Ouachita provinces.

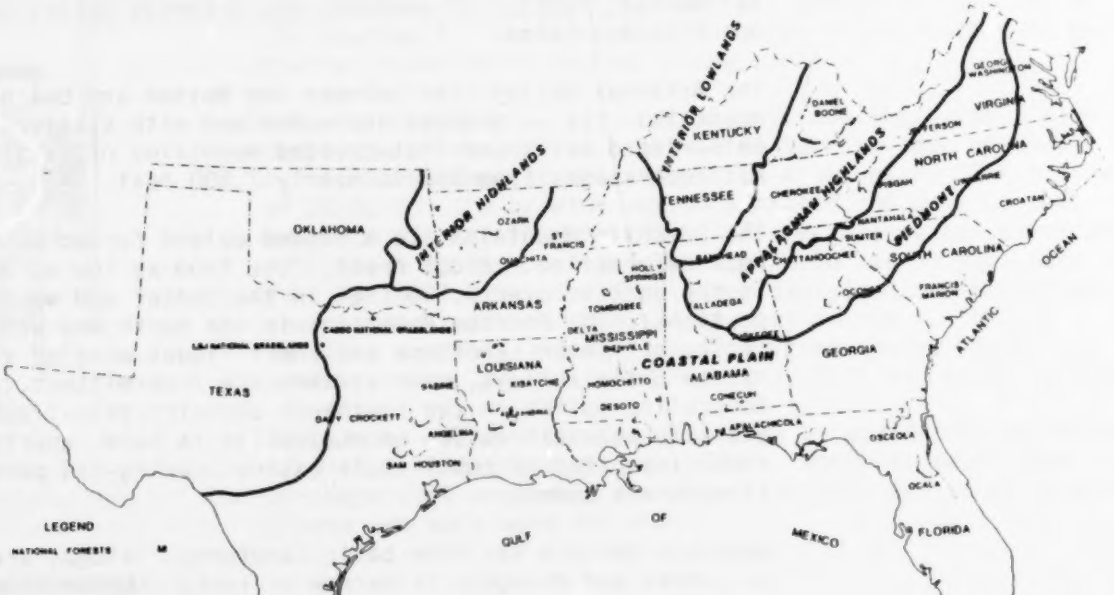

INTERIOR LOWLANDS
INTERIOR HIGHLANDS
APPALACHIAN HIGHLANDS
PIEDMONT
COASTAL PLAIN
OKLAHOMA
ARKANSAS
TEXAS
LOUISIANA
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
TENNESSEE
KENTUCKY
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
OZARK
ST FRANCIS
OUACHITA
CADDO NATIONAL GRASSLANDS
LBJ NATIONAL GRASSLANDS
SABINE
DAVY CROCKETT
ANGELINA
SAM HOUSTON
KISATCHIE
DELTA
HOLLY SPRINGS
TOMBIGBEE
BIENVILLE
HOMOCHITTO
DESOTO
TALLADEGA
CONECUH
APALACHICOLA
OSCEOLA
OCALA
BANKHEAD
CHEROKEE
CHATTAHOOCHEE
NANTAHALA
SUMTER
OCONEE
FRANCIS MARION
CROATAN
UWHARRIE
PISGAH
JEFFERSON
GEORGE WASHINGTON
DANIEL BOONE
ATLANTIC
OCEAN
GULF
OF
MEXICO
LEGEND
NATIONAL FORESTS

Figure III-1.--Physiographic subregions and States in the Forest Service's Southern Region.

(1) The OZARK PLATEAUS province in the north is a broad upland on sedimentary (water-deposited) rocks. It contains the Salem Plateau, Springfield Plateau, and Boston Mountains.

The rather flat **Salem and Springfield Plateaus** on limestone and dolomite are carved by deep meandering gorges. They have many sinking creeks and caves, such as Blanchard Caverns, and thousands of sinkholes. A mantle of chert (a hard, quartz-rich rock) covers much of the area.

The **Salem Plateau** is a rolling upland with a few broad flats incised by deep gorges having outcrops of rather old dolomite and sandstone. It has most of the area's large springs. Its altitude ranges from 300 to 1,000 feet.

The **Springfield Plateau** has steep, V-shaped valleys separated by long, narrow, winding ridges on rather young limestone and chert. Altitude is 300 to 1,400 feet.

The **Boston Mountains** are a rugged, strongly dissected plateau with flat ridges and deep narrow valleys on young sandstone and shale. Sandstone forms the flat ridges and benches on the valley sides. Altitude is 1,000 to over 2,300 feet.

(2) The OUACHITA province in the south is a series of parallel ridges and valleys formed by deformation of young sedimentary rocks. It contains the Arkansas Valley and Ouachita Mountains.

The **Arkansas Valley** lies between the Boston and Ouachita Mountains. It is a broad shale lowland with scattered thin-ridged hills and flat-crested mountains of sandstone. Altitude ranges from 500 to nearly 2,800 feet.

The **Ouachita Mountains** are a rugged upland formed by intense rock deformation. Ridge crests rise from as low as 500 feet in the east to over 2,500 feet in the center and western portions. The Fourche Mountains in the north and west are a series of linear sandstone and chert ridges mingled with narrow shale valleys; most streams are intermittent. The Novaculite Uplift in the southeast contains thin-ridged gravelly mountain masses on novaculite (a hard, quartz-rich rock) separated by small shale basins; spring-fed perennial streams are common.

Mountain terrain has five basic landforms. Ridges are flat to convex and droughty if narrow or rocky. Upper sideslopes are often straight, but lower sideslopes may be concave with deeper soils enriched in moisture due to downslope drainage. Colluvial slopes are gravity-deposited coves and benches with deep soils enriched in moisture and nutrients. Alluvial sites are stream-deposited floodplains and terraces with deep soils, also enriched in moisture and nutrients. Steep slopes are stony and may also contain rock outcrops and talus slopes with little or no soil that are droughty.

The St. Francis and Tiak units are in the Coastal Plain. The St. Francis lies astride silt-covered Crowley's Ridge in the Mississippi Valley. The Tiak includes subdued ridges and floodplains of the Little and Red Rivers. More detailed descriptions of Coastal Plain physiography are in the Final EIS for vegetation management in the Coastal Plain/Piedmont (USDA Forest Service 1989).

2. Climate

The Ozark Plateaus have a humid continental climate with hot, humid summers and cool winters. The Ouachitas and Coastal Plain have a subtropical climate with mild winters. Gulf air masses dominate the weather. Spring and summer have frequent thunderstorms, the most severe of which produce tornadoes. Winter precipitation is caused mostly by frontal systems.

Annual precipitation ranges from 45-50 inches in the Coastal Plain, Salem and Springfield Plateaus and Arkansas Valley to nearly 60 inches on high ridges in the Boston and Ouachita Mountains. Precipitation falls 95-110 days per year. Even the driest summer month receives at least two inches of rain in most years. But spring and summer droughts are common and fall is the driest season. Thunderstorms occur 50-60 days per year. Rainfall intensities generally increase to the southwest. Annual snowfall ranges from 4 inches in the Coastal Plain to 12 inches in the north.

Temperatures drop as altitude or latitude increases. July temperatures range from highs of 90-95 F to lows of 65-70 F. January temperatures range from highs of 50-55 F to lows of 25-35 F. The growing season averages 180 days in the north to 220 days in the Coastal Plain. Temperatures exceed 90 F about 60 days per year in the north and 90 days per year in the south. Freezing temperatures occur 60 days per year in the south to 90 days per year in the north. Relative humidity averages 65-70 percent, being highest in winter and early summer and lowest in fall and early spring.

Topography affects the local climate by modifying the amount of direct sunlight a site receives. North to east slopes are more cool and moist than flat terrain, and south to west slopes are more warm and dry.

B. ENVIRONMENTAL ELEMENTS

1. Vegetation

a. Forest

Vegetation within the Ozark/Ouachita forest area is comprised of mixtures of species that vary by elevation, slope position, aspect, and steepness; landform; and soil type. These factors define a site's temperature, moisture, and nutrient regimes. Temperature regime depends on amount of solar energy received. Moisture regime depends on amount of water received and stored versus amount of solar energy received. Nutrient regime depends on the type of rock a soil develops from and on its erosion and deposition history.

Slope aspect and steepness change the amount of solar energy a site receives. North to east slopes receive less direct solar energy than flat terrain and so are cooler and wetter (mesic). South to west slopes receive more direct energy and so are warmer and drier (xeric). In general, slopes can be grouped into five classes grading from wettest to driest as follows: northeast/north, east/northwest, southeast, south/west, and southwest. These differences are more pronounced for steeper slopes. Topographic shading can greatly increase site moisture in deep valleys and gorges.

Landform affects a site's moisture and nutrient status. Convex ridges drain promptly and may be droughty if narrow or rocky, and they often have thin topsoil and low fertility. Rocklands (rock outcrops and talus slopes) drain quickly, have little or no soil, and are droughty and sterile. Moisture and fertility increase downslope due to downhill movement of soil water and enhanced soil formation. Colluvial coves and benches and alluvial floodplains and terraces are enriched in moisture and nutrients deposited from upslope and upstream.

Soil depth is directly related to moisture storage capacity, usually increasing from ridges and rocklands to lower slopes to colluvial and alluvial sites. Moisture storage increases from sandy to clayey to loamy soils. The more rock fragments a soil has, the less moisture it can store.

Geology determines soil minerals. Soils derived from sandstone and novaculite tend to be more acidic and less fertile than those weathered from shale, limestone, and dolomite.

These factors combine to affect a site's growth environment. For example, most of a northeast slope may be cool and moist, while such sites on an equivalent southwest slope may be limited to lower slopes or coves where enhanced slope drainage and soil formation can compensate for the greater solar energy striking the slope.

Some plants demand more moisture and nutrients than others for optimum growth. More demanding plants tend to be better suited to north and east slopes; lower slopes and colluvial and alluvial sites; and deep, neutral, loamy to clayey soils with little rock. Species that compete best under these cooler wetter conditions include yellow-poplar, northern red oak, sugar maple, black walnut, black cherry, white ash, cucumber tree, American basswood, boxelder, red maple, and sugarberry. Less demanding plants tend to be better suited to south and west slopes; ridges, upper slopes, and rocklands; and shallow, acid, sandy or rocky soils. Effective competitors under these warmer, drier conditions include blackjack oak, post oak, chinkapin oak, black oak, black hickory, eastern redcedar, and shortleaf pine.

Over the years several classification systems have been developed to group regional vegetation associations. These systems have focused on climatic, geographic, historic, and potential (biological) vegetation occurrence. Of the many systems developed, three commonly used are Braun's (1950) description of forest regions, Kuchler's (1966) potential natural vegetation, and Bailey's (1980) ecoregions. This section uses Braun's (1950) description of forest regions to give a general description of the Ozark/Ouachita area.

No one system necessarily describes in detail the overstory, midstory, and understory of forests, so examples of some common woody species appear in tables III-2 and III-3. Examples of herbaceous species are given in the range discussion. More detailed descriptions of specific forest cover types, vegetation associations, and plant communities can be found in Forest Land and Resource Management Plans, FSH 2409.26, and publications by Arend and Odell (1948), Barbour, Burk, and Pitts (1980), Barrett (1980), Johnson and

Schnell (1985a, 1985b), Johnson (1986), and Oosting (1956). Three broad forest vegetation regions occur in the Ozark/Ouachita area:

(1) Oak-hickory forests attain their best development and highest variety of species composition in the Interior Highlands division (Braun 1950), which includes the Ozark Plateaus and Ouachita physiographic provinces. Kuchler (1966) also classified these forests as oak-hickory, and Bailey (1980) classified them to be within parts of the oak-hickory forests of the Eastern Deciduous Forest Province and also within part of the Southeastern Mixed Forest Province.

These forests are dominated by a wide variety of oak species along with many hickories. They cover approximately 4.2 million acres of Federal, State and private ownerships within counties that contain National Forest System lands in Arkansas and Oklahoma. Species of oak that occur in these forests include white oak, black oak, post oak, blackjack oak, chinkapin oak, southern red oak, shumard oak, and northern red oak. Characteristic species of hickory include black hickory, pignut hickory, mockernut hickory, bitternut hickory, and shagbark hickory.

Shortleaf pine is a common component of many of these forests. On some sites, especially those with southern and western exposures, it shares dominance with oak species and also naturally occurs in pure stands (Braun 1950). On some sites with more northern or eastern exposures or on lower slopes, species such as sugar maple, American beech, American basswood, umbrella magnolia, cucumbertree, Ohio buckeye, eastern redbud, and black walnut are found.

Other tree species associated with oak-hickory forests include serviceberry, dogwood, American elm, blackgum, sweetgum, red maple, and black cherry. Common shrubs and vines include various blueberries, blackberries, coralberry, Virginia creeper, American elder, fragrant sumac, and witch-hazel. A more comprehensive list of typical woody species of oak-hickory forests is found in table III-1.

(2) Oak-pine forests cover approximately 3.6 million acres of Federal, State, and private ownerships within counties that contain National Forest System lands. Many people recognize these as shortleaf-loblolly-hardwood forests. These forests are recognized as containing mixtures of both pine and hardwood species. Kuchler (1966) classified these forests as oak-hickory-pine, while Bailey (1980) classified them as part of the Southeastern Mixed Forest Province.

Shortleaf pine, with minor amounts of loblolly pine, predominates. Hardwoods may be codominant with pine, especially on north- to east-facing slopes. On south- to west-facing slopes, shortleaf pine is generally the dominant species. Significant hardwood mid- and understories are characteristic of these forests. Most common are many species of oak and hickory, along with dogwood, persimmon, sassafras, sweetgum, elm, redcedar, yellow poplar, black tupelo, and red maple. Common shrubs and vines include American beautyberry, hawthorns, blueberries, viburnums, greenbriers, blackberry, yellow jessamine, honeysuckle, and grape. A more comprehensive list of typical woody species of oak-pine forests is found in table III-1.

While the oak-hickory forests are more dominant in the Ozark Plateau province, and oak-pine forests are more dominant in the Ouachita province, Braun (1950) recognized that "the transition from the Oak-Hickory to the Oak-Pine region is indicated by the strong admixture of pine in the Ouachita Mountains, and by the occurrence of oak-hickory communities on the Coastal Plain of southern Arkansas in the Oak-Pine region. An area of overlap rather than a boundary lies between these two regions."

(3) Southern floodplain (bottomland) forests cover over 438,000 acres of Federal, State, and private ownerships within counties that contain National Forest System lands and are interspersed throughout the entire Ozark/Ouachita area within oak-hickory and oak-pine forests. In Bailey's (1980) ecoregions they are within both the Southeastern Mixed and Outer Coastal Plain Provinces.

These bottomland or floodplain forests occupy areas along streams, rivers, lakes, and swamps. Many of these areas are subject to periodic flooding. Common tree species include red maple, sugarberry, river birch, sweetgum, water hickory, black tupelo, American elm, sycamore, cottonwood, cherrybark oak, water oak, willow ash, and baldcypress. Shrubs and vines include buttonbush, swamp privet, fringetree, strawberry bush, possumhaw, trumpet creeper, Japanese honeysuckle, and greenbriar. A more comprehensive list of typical woody species of southern bottomland forests is found in table III-2.

b. Range

Range vegetation in the Ozark/Ouachita area is divided into three cover types: wet meadows, conifer, and hardwood. See figure III-2.

Wet meadows are areas dominated by herbaceous species that generally maintain continuous growth during most of the growing season and have seasonally wet periods that prohibit grazing. In these areas, sedges, rushes, grasses, and forbs along with occasional shrubs predominate.

Table III-1.--Some representative woody species of Ozark/Ouachita oak-hickory and oak-pine forests

Trees:

Common Name	Scientific Name	Common Name	Scientific Name
Red maple	*Acer rubrum*	Black tupelo, blackgum	*Nyssa sylvatica*
Ohio buckeye	*Aesculus glabra*	Eastern hophornbeam	*Ostrya virginiana*
Serviceberry	*Amelanchier arborea*	Shortleaf pine	*Pinus echinata*
American hornbeam, ironwood	*Carpinus caroliniana*	Loblolly pine	*Pinus taeda*
		Black cherry	*Prunus serotina*
Bitternut hickory	*Carya cordiformis*	White oak	*Quercus alba*
Pignut hickory	*Carya glabra*	Southern red oak	*Quercus falcata*
Shagbark hickory	*Carya ovata*	Shingle oak	*Quercus imbricaria*
Black hickory	*Carya texana*	Bur oak	*Quercus macrocarpa*
Mockernut hickory	*Carya tomentosa*	Blackjack oak	*Quercus marilandica*
Hackberry	*Celtis occidentalis*	Chinkapin oak	*Quercus Muehlenbergii*
Eastern redbud	*Cercis canadensis*	Northern red oak	*Quercus rubra*
Flowering dogwood	*Cornus florida*	Shumard oak	*Quercus shumardii*
Common persimmon	*Diospyros virginiana*	Post oak	*Quercus stellata*
American beech	*Fagus grandifolia*	Black oak	*Quercus velutina*
White ash	*Fraxinus americana*	Black locust	*Robinia pseudoacacia*
Black walnut	*Juglans nigra*	Western soapberry	*Sapindus drummondii*
Eastern redcedar	*Juniperus virginiana*	Sassafras	*Sassafras albidum*
Sweetgum	*Liquidambar styraciflua*	American basswood	*Tilia americana*
Yellow-poplar	*Liriodendron tulipifera*	Winged elm	*Ulmus alata*
Umbrella magnolia	*Magnolia tripetala*	American elm	*Ulmus americana*
Cucumbertree	*Magnolia acuminata*		

Shrubs and Vines:

Common Name	Scientific Name	Common Name	Scientific Name
Pawpaw	*Asimina triloba*	Poison oak	*Rhus toxidodendron*
American beautyberry	*Callicarpa americana*	Blackberry	*Rubus* spp.
New Jersey tea	*Ceanothus americanus*	American elder	*Sambucus canadensis*
Fringetree	*Chionanthus virginicus*	Saw greenbrier	*Smilax bona-nox*
Hawthorns	*Crataegus* spp.	Cat greenbrier	*Smilax glauca*
Eastern burningbush	*Euonymus atropurpureus*	Common greenbrier	*Smilax rotundifolia*
Yellow jessamine	*Gelsemium sempervirens*	Coralberry	Symphoricarpos *orbiculatus*
Witch-hazel	*Hamamelis virginiana*		
Winterberry, possumhaw	*Ilex decidua*	Common sweetleaf	*Symplocus tinctoria*
Japanese honeysuckle	*Lonicera japonica*	Sparkleberry	*Vaccinium arboreum*
Virginia creeper	*Parthenocissus quinquefolia*	Deerberry	*Vaccinium stamineum*
		Dryland blueberry	*Vaccinium vacillans*
Dwarf chinkapin oak	*Quercus prinoides*	Arrowwood	*Viburnum dentatum*
Fragrant sumac	*Rhus aromatica*	Rusty blackhaw	*Viburnum rufidulum*
Shining sumac	*Rhus copallina*	Summer grape	*Vitis aestivalis*
Smooth sumac	*Rhus glabra*	Muscadine grape	*Vitis rotundifolia*
Poison ivy	*Rhus radicans*		

Table III-2.—Some representative woody species of Ozark/Ouachita bottomland forests

Trees:

Common Name	Scientific Name	Common Name	Scientific Name
Boxelder	Acer negundo	Red mulberry	Morus rubra
Red maple	Acer rubrum	Black tupelo	Nyssa sylvatica
Silver maple	Acer saccharinum	Shortleaf pine	Pinus echinata
Sugar maple	Acer saccharum	Loblolly pine	Pinus taeda
River birch	Betula nigra	Water elm	Planera aquatica
American hornbeam, ironwood	Carpinus caroliniana	Eastern cottonwood	Populus deltoides
		Sycamore	Platanus occidentalis
Water hickory	Carya aquatica	Cherrybark oak	Quercus falcata var. pagodaefolia
Bitternut hickory	Carya cordiformis		
Pecan	Carya illinoensis	Shingle oak	Quercus imbricaria
Sugarberry	Celtis laevigata	Overcup oak	Quercus lyrata
Hackberry	Celtis occidentalis	Bur oak	Quercus macrocarpa
Eastern redbud	Cercis canadensis	Swamp chestnut oak	Quercus michauxii
Flowering dogwood	Cornus florida	Water oak	Quercus nigra
Common persimmon	Diospyros virginiana	Nuttall oak	Quercus nuttallii
American beech	Fagus grandifolia	Pin oak	Quercus palustris
Green ash	Fraxinus pennsylvanica	Willow oak	Quercus phellos
Waterlocust	Gleditsia aquatica	Shumard oak	Quercus shumardii
Honeylocust	Gleditsia triacanthos	Black willow	Salix nigra
American holly	Ilex opaca	Baldcypress	Taxodium distichum
Black walnut	Juglans nigra	American elm	Ulmus americana
Sweetgum	Liquidamber styraciflua	Cedarelm	Ulmus crassifolia
Cucumbertree	Magnolia acuminata	Black locust	Robinia pseudoacacia
Umbrella magnolia	Magnolia tripetala	Slippery elm	Ulmus rubra
Water tupelo	Nyssa aquatica		

Shrubs and Vines:

Common Name	Scientific Name	Common Name	Scientific Name
Red buckeye	Aesculus pavia	Carolina jessamine	Gelsemium sempervirens
Peppervine	Ampelopsis arborea	Waterberry, possumhaw	Ilex decidua
Devils walking stick	Aralia spinosa	Virginia willow	Itea virginica
Pawpaw	Asimina triloba	Japanese honeysuckle	Lonicera japonica
Supplejack	Berchemia scandens		
Trumpet creeper	Campsis radicans	Yellowood	Rhamnus caroliniana
Button bush	Cephalanthus occidentalis	Poison ivy	Rhus radicans
		Poison sumac	Rhus vernix
Fringetree	Chionanthus virginicus	American elder	Sambucus canadensis
Roughleaf dogwood	Cornus drummondii	Laurel greenbrier	Smilax laurifolia
Hawthorn	Crataegus spp.	Common greenbrier	Smilax rotundifolia
Strawberry bush	Euonymus americanus	Sparkleberry	Vaccinium arboreum
Eastern burningbush	Euonymus atropurpureus	Possumhaw viburnum	Viburnum nudum
Swamp privet	Forestiera acuminata	Blackhaw	Viburnum prunifolium

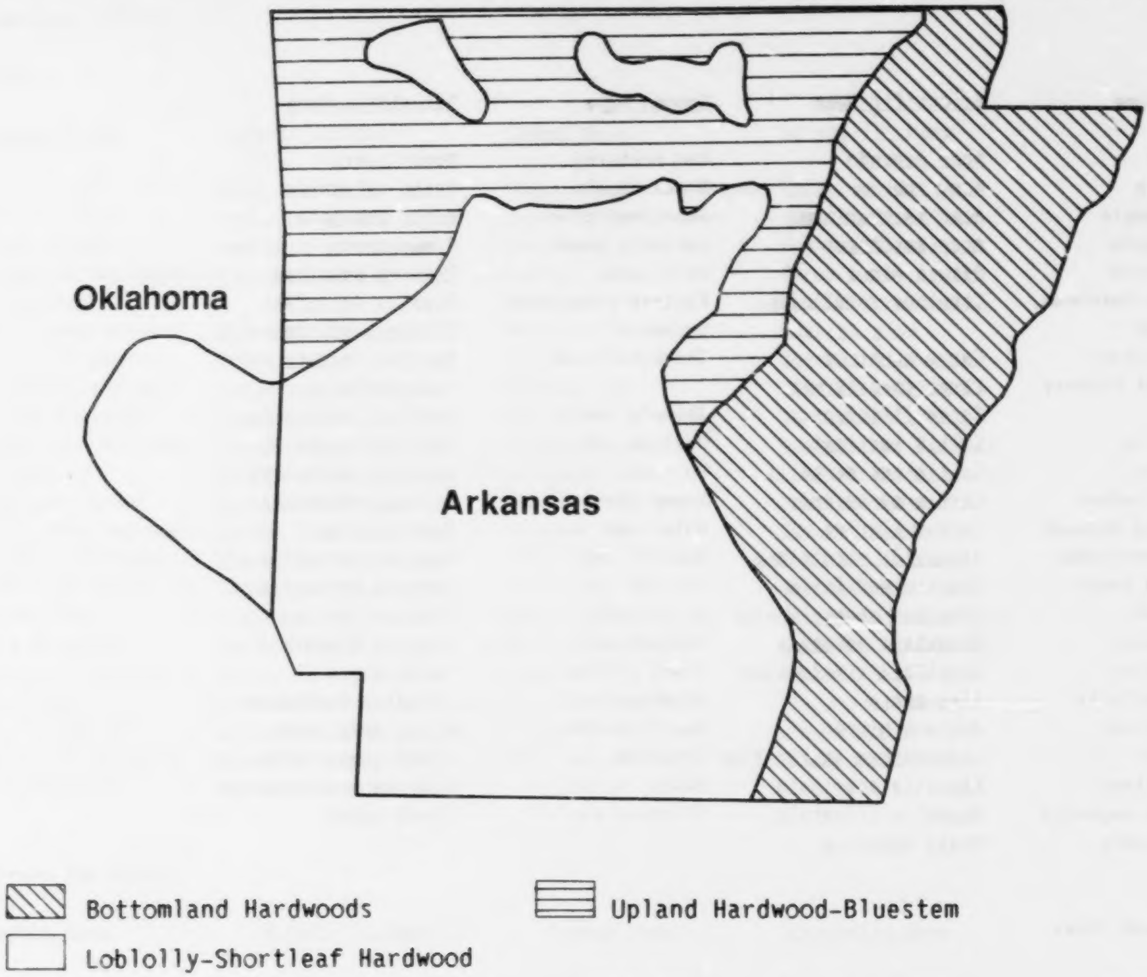

Oklahoma
Arkansas
▧ Bottomland Hardwoods
▤ Upland Hardwood-Bluestem
☐ Loblolly-Shortleaf Hardwood

Figure III-2.--Forest range types of the Ozark/Ouachita.

Herbaceous range plants grow within *conifer* and *hardwood* forests. These categories occur as understory species within the previously described forests. The more important woody browse species are discussed in the forest vegetation section and listed in tables III-1 and III-2.

Within oak-hickory and oak-pine forests, common native range forage grass species include little bluestem (*Schizachyrium scoparium*), broomsedge bluestem (*Andropogon virginicus*), big bluestem (*A. gerardii*), silver plumegrass (*Erianthus alopecuroides*), purpletop (*Tridens flavus*), poverty oatgrass (*Danthonia spicata*), indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and woolly panicum (*P.*

lanuginosum). Grass-like plants (sedges and rushes) common to this area include the early sedge (*Carex artitecta*), blue sedge (*C. complanata*), lurid sedge (*C. lurida*), twinflower rush (*Juncus biflorus*), path rush (*J. interior*), and poverty rush (*J. tenuis*).

Common forbs, comprised mainly of legumes and composites, include whorled milkweed (*Asclepias verticillata*), white heath aster (*Aster pilosus*), partridgepea (*Cassia fasciculata*), dittany (*Cunila origanoides*), roundleaf tickclover (*Desmodium rotundifolium*), pale coneflower (*Echinacea pallida*), fireweed (*Erechtites hieracifolia*), white snakeroot (*Eupatorium rugosum*), lespedeza (*Lespedeza procumbens*), southern bracken-fern (*Pteridium aquilinum*), slender mountainmint (*Pycnanthemum tennuifolium*), black-eyed susan (*Rudbeckia hirta*), goldenrod (*Solidago* spp.), goat's rue (*Tephrosia virginiana*), and birdsfoot violet (*Viola pedata*).

Most of the range resources are associated with improved pastures, regeneration areas, and openings within oak-pine forests.

In 1988 on the Ozark/Ouachita national forests 3,543 cattle and 15 horses used approximately 44,000 animal unit months of forage on 185 range allotments totalling nearly 1 million acres.

c. Wilderness

There are 130,059 acres of wilderness in the Ozark-St. Francis and Ouachita National Forests. Wilderness areas vary in size from 6,310 to 16,956 acres. The wilderness system includes hardwood river bottoms, steep sideslopes, cliffs, and high peaks. A wide variety of plants and animals occupy these wilderness areas.

Vegetation management is not generally practiced in wilderness areas, but natural or prescribed fire may be necessary to ensure protection of rare and endangered species and reduce unnatural fuel buildups. Other vegetation management practices such as trail maintenance are minor.

d. Fire Management and Fuel Types

Periodic natural and man-caused fires have heavily influenced forests of the Interior Highlands. Shortleaf and loblolly pine are fire-dependent subclimax species that are naturally maintained by fire or other disturbances such as tornadoes. These pines and many upland hardwoods (especially oaks) have adapted to periodic burning regimes, especially on south- to west-facing slopes that are more exposed to sunlight and prevailing winds (Johnson and Schnell 1985a, 1985b; Turner 1935).

Lightning fires, and those set by Indians and settlers, were important in establishing and maintaining these species in most areas (Johnson and Schnell 1985a, 1985b). Fire protection since the 1930's has greatly reduced fire's role in the forests (Liming and Johnston 1944). As a result, the hardwood component of pine stands has increased, while the oak component of hardwood stands and fire-dependent ecosystems have declined.

From 1983 to 1988 an average of 180 wildfires burned about 2,300 acres each year. Lightning caused an average of 33 fires per year. Numbers of fires and their severity are greatly influenced by cyclic incendiary and drought conditions.

Today, prescribed fire is used mostly to reduce hazardous fuels, improve wildlife habitat and range forage, prepare sites for pine and hardwood regeneration, and maintain fire-dependent ecosystems. Average annual acres treated by prescribed fire on the national forests are approximately:

1.	Hazardous fuels	14,500
2.	Wildlife habitat (including T&E)	33,500
3.	Range forage	2,980
4.	Site preparation	5,010
5.	Other	160
		56,150

Climate and physiography of the Interior Highlands support five major fuel types with varying burning characteristics. Fire intensity in any fuel type varies much with topography, weather (rainfall, humidity, wind) and the amount, size distribution, degree of concentration, moisture content and chemistry of available fuels. In general, more fuels become available during periods of low live fuel moisture, as in fall and winter when vegetation is dormant or in spring and summer droughts. The major fuel types are:

a. **Hardwood** on damp coves to dry ridges. Available fuels can include leaf litter, down dead wood and standing snags. Fuel loads are light to moderate and support low intensity surface fires. Moisture varies greatly across the array of landforms, so fuels may burn on ridges and south-to-west slopes when they can't burn in coves, lower slopes and north-to-east slopes. The entire St. Francis unit occurs in this type.

b. **Pine** including natural pine stands and pine plantations (after crown closure) mostly on dry sites. Available fuels can include needle litter, scattered hardwood brush, down dead wood and standing snags. Fuel loads are moderate and normally support rather slow moving, low to medium intensity surface fires.

c. **Hardwood-pine** on dry to damp sites. Overstory is mixed, being mostly pine in the Arkansas Valley, Ouachita Mountains and Tiak unit and mostly hardwood in the Boston Mountains and Salem and Springfield Plateaus. Available fuels can include leaf and needle litter, hardwood brush, down dead wood and standing snags. Fuel loads are light to moderate and support low to medium intensity surface fires.

d. **Grass-brush** including pastures, open pine plantations and cedar glades. Available fuels can include litter, grass and forbs, standing snags, down dead wood, and scattered hardwood brush. Fuel loads are light but can support rapid, rather intense surface fires when dry. Such fires often involve pine foliage in plantations.

e. **Logging slash** resulting from harvest cuts and thinnings. Available fuels can include all living, dead and cut down plant materials. Fires can be very intense if slash is dry, heavy and concentrated.

2. Wildlife

Ozark and Ouachita Mountain ecosystems support a great variety of terrestrial life. This variety reflects the range of climatic conditions, forest types, aspect, and successional stages on the national forests.

Big-game species include white-tailed deer (Odocoileus virginianus), eastern wild turkey (Meleagris gallopavo), and black bear (Ursus americanus). Important small-game species are bobwhite quail (Colinus virginianus), eastern mourning dove (Zenaida macroura), cottontail rabbit (Sylvilagus floridanus), gray squirrel (Sciurus carolinensis), fox squirrel (Sciurus niger), and several species of waterfowl. Major fur-bearing species include opossum (Didelphis virginiana), raccoon (Procyon lotor), gray fox (Urocyon cinereoargenteus), bobcat (Lynx rufus) and coyote (Canis latrans).

Other wildlife species characteristic of Ozark and Ouachita Mountain ecosystems include the pileated woodpecker (Dryocopus pileatus), red-tailed hawk (Buteo jamaicensis), red-shouldered hawk (Buteo lineatus), barred owl (Strix varia), eastern bluebird (Sialia sialis), nine-banded armadillo (Dasypos novemcinctus), southern flying squirrel (Glaucomys volans), and beaver (Castor canadensis). Thousands of other species of amphibians, reptiles, birds, mammals, and invertebrates also live in or near the national forests.

The Forest Service, along with the Arkansas Game and Fish Commission and the Oklahoma Division of Wildlife Conservation, routinely manage habitat for game and nongame wildlife. The two state agencies are responsible for establishing hunting and fishing regulations and law enforcement. These efforts of the Forest Service and other agencies are integrated and coordinated through cooperative programs for the benefit of the wildlife resource.

3. Threatened, Endangered, Proposed, and Sensitive Species

Nine animal species classified by the Fish and Wildlife Service as threatened or endangered (or proposed for listing as threatened or endangered) live in the Ozark and Ouachita National Forests. These species include two mammals, four birds, one reptile, and two mollusks. There are no threatened or endangered plant species on either forest. Habitats of these species are managed under authority of the Endangered Species Act with the goal of population recovery. Appendix E lists these species and describes their habitats.

In addition, certain species for which population viability is a concern are designated by the Regional Forester as sensitive. This designation is normally established with concurrence and guidance of appropriate State Heritage Agencies. Habitats of sensitive species are managed to ensure population levels which will keep these plants and animals from becoming threatened or endangered. Appendix E lists species currently designated as sensitive, and species being reviewed by the U.S. Fish and Wildlife Service for possible addition to the List of Endangered and Threatened Species under the Endangered Species Act of 1973, as amended, and describes their habitats.

4. Soils

Soils of the Ozark/Ouachita Mountains vary with geology, climate and topography. Four soil orders occur extensively in this region.

a. Ultisols are highly developed acid soils with strong clay buildup in subsoil and intense leaching of bases. These loamy to clayey soils are usually rather deep and contain few rock fragments but can be shallow and stony. They are most common on ridges, sideslopes and gently sloping areas.

b. Alfisols are well developed soils with some clay buildup in subsoil and slight leaching of bases. These loamy to clayey soils are usually rather deep. Alfisols on the St. Francis unit are deep soils developed from wind-deposited silt (loess) with few rock fragments. Those in the mountains are most common on coves, terraces and benches and may be rocky.

c. Inceptisols are poorly developed loamy and clayey soils. Those on ridges and sideslopes are often shallow and rocky with thin topsoil and little clay buildup in subsoil. Those in coves and floodplains are usually deep with thick topsoil and weak subsoil.

d. Entisols are undeveloped, acid loamy soils. They occur in floodplains and are often deep with thick topsoil and very weak or no subsoil.

Productivity of these soils depends much on their geology, topography and land-use history. Soils severely eroded or disturbed by past farming, mining or careless logging may be seriously deficient in organic matter and nutrients, most of which occur in topsoil. Inceptisols on ridges and sideslopes are often unproductive due to low moisture storage and fertility. Ultisols and alfisols are rather productive, more so on wetter north-east and lower slopes and in the Coastal Plain. Inceptisols and entisols in coves and floodplains, enriched in moisture and nutrients deposited from upslope and upstream, are the most productive soils.

Erosion hazard increases with slope steepness and is usually higher in weakly cemented or clayey soils. Landslide hazard is highest on steep slopes with shallow or clayey soils. Compaction hazard is highest in clayey soils and in poorly drained floodplains and coves.

5. Water and Aquatic Life

The humid climate of the Interior Highlands produces abundant water. Annual runoff is 15-20 inches, but as high as 20-25 inches in high headwater streams of the Ouachita Mountains. Streamflows are usually highest in spring and lowest in late summer.

a. Surface Water

The national forests contain about 2,400 miles of perennial streams. Perennial streams are most common in the Salem and Springfield Plateaus and the southern Ouachita Mountains where springs are abundant. Many streams in the Boston and northern Ouachita Mountains and Arkansas Valley are intermittent, with scattered pools fed by subsurface flow in the summer. Natural lakes are rare, but many reservoirs with high quality water have some national forest shoreline. Streams draining watersheds with substantial national forest land provide public water for many communities.

Surface water quality is excellent in most streams except during major storms. Major sources of sediment are mines, roads, farms and construction sites. Potential sources of chemical pollution are coal mines in the Arkansas Valley and barite mines and pyrite-rich rocks in the Ouachita Mountains that can produce acid runoff.

In the mountains, moderate slopes and stream densities create moderate potential for increased erosion and sediment loads. Floodplains are narrow and streambeds have steep gradients and rapid response to storms. In the Salem and Springfield Plateaus, limestone and dolomite produce neutral surface water high in dissolved minerals. Elsewhere, sandstone and novaculite produce neutral surface water low in dissolved minerals.

In the Salem and Springfield Plateaus, stream gradients are steep and uniform and streambeds are almost totally gravel and rubble. In the Boston Mountains, stream gradients are very steep and streambeds are mixed rubble, sand, bedrock, and gravel. In the Arkansas Valley, stream gradients are moderate and streambeds are mostly bedrock, rubble, and boulders. In the Ouachita Mountains, stream gradients are steep and stepped with many rapids and chutes; streambeds are mostly gravel and rubble (Giese and others 1987).

In the St. Francis unit, moderate slopes, dense drainage networks and erodible silts create very high potential for increased erosion and sediment loads. Streams are narrow and deeply cut, and intense rains can produce much sediment from gullies. In the Tiak unit, gentle slopes and level, sand-bedded streams meandering through broad floodplains create low potential for increased erosion and sediment loads.

b. Aquatic Life

Diverse aquatic habitats of the Interior Highlands support over 400 species of fish, reptiles, amphibians, mollusks and aquatic insects. The three basic habitat types are streams, lakes and ponds (Robinson and Buchanan 1988).

Streams contain the greatest diversity of species, including many fish and invertebrates listed as sensitive. Streams are divided into coolwater and warmwater habitats.

The 2,000 miles of coolwater streams support small mouth bass (Micropterus dolomieui), shadow bass (Amblopites ariommus), longear sunfish (Lepomis megalotis), green sunfish (Lepomis cyanellus), northern hogsucker (Hypentilium nigricans), darters (Etheostoma sp.) and madtom catfishes (Noturus sp.). Aquatic insects are the food base of these fish. Some species of mayflies, stoneflies, caddisflies, crayfish and mussels are very sensitive to water quality changes.

Coolwater streams occur mostly in the Salem and Springfield Plateaus and the Boston and Ouachita Mountains. Coldwater species such as brown (Salmo trutta) and rainbow trout (Salmo gairdneri) occur below hydroelectric dams and in put-and-take fisheries.

The 400 miles of warmwater streams support spotted bass (Micropterus punctulatus), largemouth bass (Micropterus salmoides), channel catfish (Ictalurus punctatus), blue catfish (Ictalurus furcatus), flathead catfish (Pylodicits olivaris), pirate perch (Aphredoderus sayanus), redhorse (Moxostoma sp.) and minnows (Notropis sp.). Warmwater streams occur mainly in the Arkansas Valley and the Coastal Plain. Minnows and darters listed as sensitive are found in these streams.

Lakes totaling 4,000 acres support hybrid striped bass (Morone saxatilis x chrysops), largemouth bass, walleye (Stizostedion vitrium), bluegill sunfish (Lepomis macrochirus), crappie (Pomoxis spp.) and other species. Gizzard and threadfin shad (Dorosoma spp.) are examples of several forage fish species. Many lakes are stocked with channel catfish.

Ponds typically contain largemouth bass, bluegill sunfish and channel catfish. Ponds larger than 0.5 acre are usually managed for fish. Many wildlife and range ponds are smaller than 0.5 acre and are managed for amphibians.

c. Ground Water

Deeper limestones and dolomites in the Salem and Springfield Plateaus yield large amounts of hard ground water high in calcium bicarbonate. Valley deposits of the Mississippi, Red, Ouachita and White Rivers are also productive aquifers, but water is often hard and high in iron. Other rocks yield little ground water that is usually hard and high in iron, so most use comes from surface sources. Ground water is readily contaminated in karst terrain of the Salem and Springfield Plateaus with sinking creeks, sinkholes and caverns.

d. Wetlands

The only known wetlands occupy 20 acres in floodplains on the Tiak unit. Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands) protect the ability of floodplains to moderate floods and that of wetlands to produce abundant and diverse biota, regulate water flow and quality and recharge ground water.

6. Air

In the dormant season, air flow and quality are dominated by migrating, frequently changing air masses and storm systems. In the growing season, air flow and quality are dominated by the Atlantic high-pressure system whose clockwise movement pumps in tropical air from the Gulf of Mexico. Prevailing winds are typically from the northwest from October to March, and from the southwest from April to September.

Air quality is generally good in winter and spring when rapidly changing weather patterns tend to keep the atmosphere well mixed. Occasional stagnation periods in summer and fall cause natural and manmade pollutants to build up. Stagnation is worsened in valleys where pollutants are trapped by surrounding hills and nighttime downslope air flows.

No major industries or cities are near enough to the southwest, west or northwest to allow prevailing winds to carry in significant pollutants. However, a power plant in extreme northwest Arkansas sometimes affects air quality in parts of the Boston Mountains. Local pollution can be serious in populated valleys. Occasionally, northeast winds bring in pollutants from the northeastern United States.

Geographic areas are typed as either Class I, II, or III. Class I areas are thought to have the best air quality and are mandated special protection. Air quality in Class II and III areas exceeds National Ambient Air Quality Standards set by the Environmental Protection Agency, but protection is not as stringent as in Class I areas. The two Class I areas that might be affected by vegetation management are the Upper Buffalo Wilderness in the Boston Mountains and the Caney Creek Wilderness in the Ouachita Mountains. All other national forest lands are Class II. Other areas that might be affected are highways, airports, and populated areas downwind from national forests.

7. Rights-of-Way Corridors

Rights-of-way include roads, trails, utility corridors, and railroads. Historically, vegetation management programs for rights-of-way maintenance have included the full range of options including manual, mechanical, biological, fire, and herbicides.

a. Roads

Roadside vegetation is managed to protect investments and to provide user safety in concert with the road's intended use. Forest Service roads in the Ozark/Ouachita Mountains area total 8,220 miles. Using mostly mechanical methods, crews maintain about 9,200 acres of vegetation along roads to one of five levels. Amount of traffic and maintenance requirements increase with each level:

Maintenance Level	Miles
1	308
2	6,126
3	1,420
4	242
5	124
Total	8,220

Highways with special designations include the Talimena Scenic Drive on the Ouachita National Forest within the Winding Stair National Recreation Area and the Sylamore Scenic Byway on the Ozark National Forest. Other scenic byways will be nominated making a total of about 200 miles with special designations.

Scenic Byway routes' publicity will attract additional use to these roads and adjacent connector roads. Driving for pleasure is a popular recreation activity that all roads provide to national forest users. Roads also provide access to recreation sites and facilities, hunting and fishing areas, timber management and other multiple use project activities.

Roads and highways maintained by other Federal, State, and county agencies and under special use permit with the Forest Service total 123 miles, requiring 1,625 acres to be maintained mostly by mechanical and herbicides with some manual methods. Vegetation management is performed on road shoulders to enhance drainage; on cut and fill slopes to provide increased sight distance; and along roadsides to control danger trees.

b. Trails

Trails provide outdoor recreation opportunities and access to scenic and cultural resources. Trailside vegetation is controlled to provide for user safety, protect the investment, and enhance trailside appearance. Manual and mechanical methods are chiefly used.

Hiking, off-road vehicle (ORV), horse, and canoe trails make up the 542 miles of trail that require vegetation management. The bulk of this mileage is hiking trails, although horseback and ORV trails are maintained.

The Ozark Highlands Trail and Ouachita Trail are National Recreation Trails requiring special vegetation management to protect recreation values. These two trails total 325 miles passing through most plant communities within the two Forests.

c. Utility Corridors

Many powerline and communication utilities have above-ground and buried cable lines through national forests. Vegetation management is performed along these areas to enhance transmission system reliability, provide public and worker safety, and access facilities. Some rights-of-way are maintained annually and others intermittently at up to 10-year intervals.

There are 1,132 miles of utility corridors of varying width that include 6,200 acres of national forest lands. About 1,200 acres are maintained each year. Vegetation control programs are used to keep trees from growing across conductors, thus preventing power outages, safety hazards, and possible forest fires from broken lines. Vegetation is also controlled along access roads. Manual, mechanical, and herbicide methods are used.

d. Pipelines

Vegetation controls are used annually on about 625 acres along 95 miles of oil and gas pipelines. These controls allow for detection of leaks, control of undesirable plants, public and worker safety, and access. Mechanical, herbicide and manual methods are used.

8. Visual Quality

The Boston and Ouachita Mountains are a series of east-west ridges and mountains with narrow to broad valleys. The Ouachita Mountains are predominately rocky steep-sided, narrow east-west ridges with narrow valleys while the Boston Mountains are more dissected with broader ridges and valleys with numerous cliff lines, pedestal rocks and some natural bridges. Elevations range from about 400 to 2800 feet above mean sea level and contain some of the most extensive hardwood forests in the region. Many rivers and streams begin in these mountains. Prominent landscape features include lakes, whitewater streams, caves, cliffs, and distinctive vegetative patterns with many varied deciduous and conifer species.

Inventoried visual quality levels are determined by "distance zone," the distance at which a landscape is viewed; "sensitivity level," the number and interest level of people viewing the scene; and "variety class," the interest and visual diversity a landscape affords.

A Visual Quality Objective (VQO)is assigned to each landscape which describes the degree of alteration permissible for each management situation. VQO's constitute a ranking which can be described as follows:

Increasing protection & enhancement of the natural landscape required ↑	1. Preservation VQO 2. Retention VQO 3. Partial Retention VQO 4. Modification VQO 5. Maximum Modification VQO	Increasing alteration of the natural landscape permitted ↓

9. Cultural Resources

Cultural resources are artifacts, buildings, or sites resulting from past human activity. They can be archaeological, historical, prehistoric, or architectural. Cultural resources are irreplaceable and of great concern to the public. Examples are remnants of old wagon roads, homesteads, Civilian Conservation Corps structures, or native American camp sites or mound complexes.

Laws and regulations require that Federal agencies manage the cultural resources under their control. Procedures are followed to assure that cultural values are considered in any decision-making process. These procedures include inventorying, evaluating, determining effects, and mitigating adverse effects.

On the Ozark, St. Francis, and Ouachita National Forests about 10 percent of the area has been inventoried at varied intensities for cultural resources. Approximately 140 historic and 700 prehistoric sites have been recorded through FY 1988.

10. Socioeconomics

Approximately 5.7 million people live in Arkansas and Oklahoma. Within the boundaries of national forests in these two States are about 1.2 million acres of private land. Private landowners include year-round residents, summer or winter residents, small businesses, absentee landowners, and a few industrial timber companies.

Population growth in the South has outpaced the nation's growth rate since 1970, and this trend is expected to continue through 1990. Arkansas and Oklahoma have not realized growth trends of many southern areas. Future population growth is projected to be less than the South as a whole. Prior to 1970, this section of the nation experienced population decline, especially in the adult population of childbearing years. Average age of the population is greater than in most other sections of the country due to young people having moved out prior to 1970 and to the influx of retirees. Population growth from 1975 to 1985 is primarily due to net in-migration (Dahmann 1986). Growth from in-migration is expected to continue (see table III-3).

Table III-3.--Population and population projections (Dahman, 1986)

State	Population (thousands)		Population Projections (thousands)	
	1977	1986	1990	2000
Arkansas	2,152	2,372	2,580	2,835
Oklahoma	2,817	3,305	3,503	3,944
Total	4,969	5,627	6,083	6,779

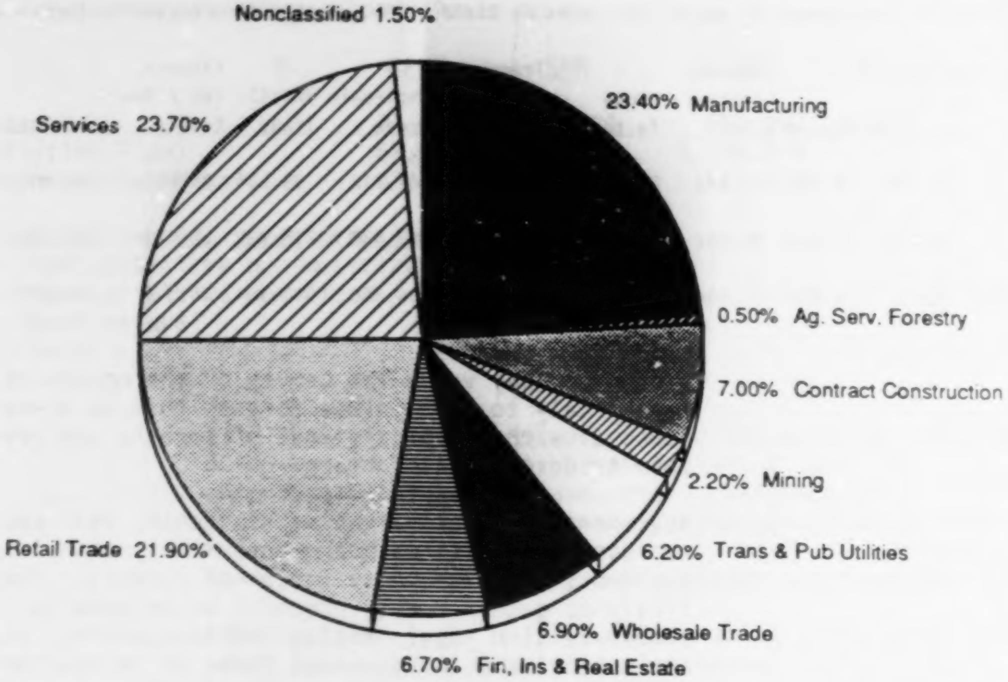
Total employment in the Region has followed population trends, with 48 percent of the population employed in 1986 (48 percent participation ratio is slightly below the U.S. ratio of 50 percent). Employment by major sector follows national trends. The Region, however, shows slightly greater dependence on government employment. Also, the small amount of durable-goods manufacturing has allowed the South to be less influenced by recessionary pressures than the rest of the nation. The Region since the 1940's has escaped severe inventory corrections that cause unemployment (Haulk 1980). As a result, unemployment rates generally have been below national averages during periods of recession. Figure III-3 displays employment by major industry in the Southern Region, and table III-4 shows employment by major industries by State, 1983.

Agriculture and related services have declined in relative importance and account for less than 10 percent of total employment in the region. The decline has been more than offset by growth in the services sector. However, most rural counties, although they make up a small part of the total population, are still very dependent on agriculture and related services for employment.

Per capita income for the South historically has been below the national average. In 1983, it averaged $8,381, which is 12 percent below the national average. Wages and salaries earned in agricultural and light industrial occupations, predominant in the South, are lower than those earned in heavy manufacturing. Projections of per capita income reflect substantial increases at national and regional levels, with proportional gains in the South.

The South has traditionally depended on forest and range resources for goods and services. Current projections indicate that these resources will become more important in the future. Land managers recognize that effects of their actions extend far beyond national forests, and that they must be familiar with relationships between natural resource management and the social and cultural environment.

People who live and work in or near the national forests have diverse expectations of forests based on differing value systems. In general, long-term residents of these areas tend to value land use; they enjoy being surrounded by forests and believe in using forests to gather products such as building stone, berries, and firewood. They also want to use forests for hunting and fishing, picnicking, boating, and swimming. Some value forests for their ability to produce tourism-related employment but others would prefer having the mountains and forests to themselves. Many long-term residents work in timber-related jobs or have relatives and friends who depend on this segment of the


EMPLOYMENT BY MAJOR INDUSTRIES
Southern Region

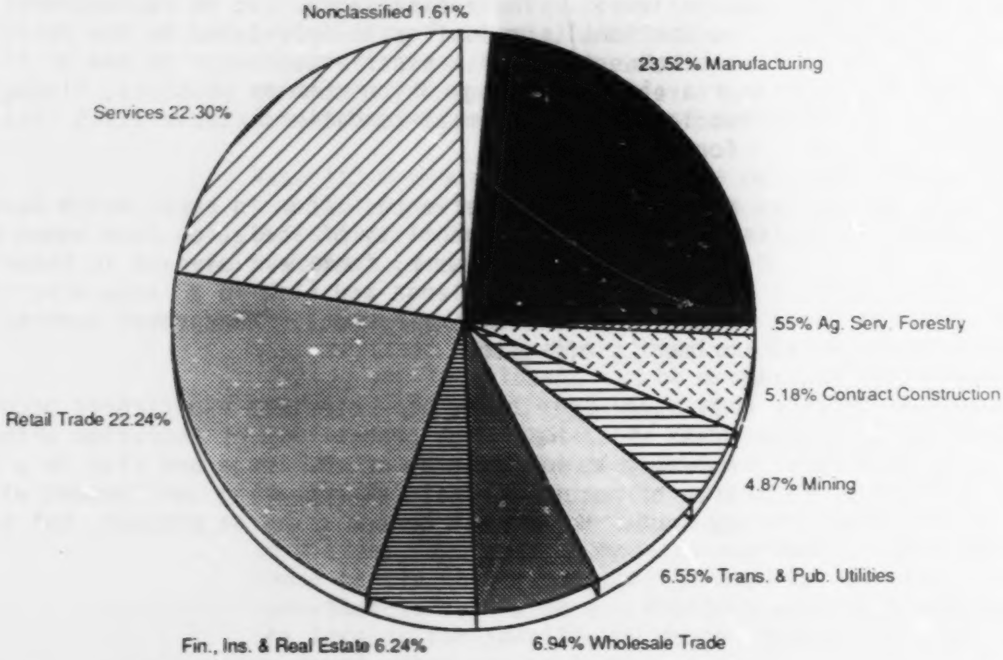

EMPLOYMENT BY MAJOR INDUSTRIES
Ozark/Ouachita Mountains

Figure III-3.--Employment by major industries (adapted from Bureau of Census data).

Table III-4.--Employment by major industries by State, 1983 (adapted from Bureau of Census data)

	Ag Serv For & Fisheries	Mining	Contract Construction	Manufacturing	Transport & other Pub Util	Wholesale Trade	Retail Trade	Finance Ins & Real Estate	Services	Non-classified	TOTAL
AR	4,224	4,896	33,823	200,085	40,252	41,212	35,229	34,886	134,608	9,605	638,820
OK	4,393	71,989	48,041	171,391	63,245	68,436	215,935	63,627	217,586	15,783	940,426
TOTAL	8,617	76,885	81,864	371,476	103,497	109,648	351,164	98,513	352,194	25,388	1,579,246

economy. They value the beauty of the mountains but are more likely to want to use forests than to preserve them. Some value the very existence of forests and need not visit them to derive satisfaction.

Newcomers, whether part-time residents, year-round residents, or retirees, are more likely than long-term residents to value preservation of forests. They are less likely to gather forest products or to work in timber-related jobs. Hiking and backpacking, and viewing are more likely to be valued forms of recreation for this group. They value preservation of the visual beauty of their new surroundings. This group is increasing its representation in the population of the area.

People's expectations of the forest are fulfilled through experiences. These experiences can be recreational, occupational, or just casually related to the daily living environment. Forest experiences occur in one of five kinds of areas or settings which combine physical, biological, social, and managerial conditions (table III-5 lists acreage for each setting):

(1) Primitive experiences occur in areas which have extremely high probability of isolation from human activity with difficult access by foot, a closeness to nature, with a high degree of challenge and risk in a large area of unmodified natural environment. Management controls are primarily off-site.

(2) Semi-primitive, non-motorized experiences occur in areas which have high probability of isolation with a moderate to high degree of challenge and risk in a large area of natural or natural appearing environment with access by foot. Management controls may be present, but subtle.

Table III-5.--Experience settings (Approximate Acres)

Forest	P	SPNM	SPM	RN	R
Ozark/St. Francis		71,000	400,000	663,000	6,000
Ouachita (Existing Plan)		62,552	163,400	1,358,948	12
Ouachita (Supplemental Plan)		63,245	193,826	1,287,023	47,755

Key: P - Primitive (No acres are classed primitive)
SPNM - Semi-primitive non-motorized
SPM - Semi-primitive motorized
RN - Road natural
R - Rural

(3) Semi-primitive, motorized experiences occur in areas which have moderate degrees of isolation, but some opportunity for vehicle use, risk, challenge and self-reliance in a predominately natural-appearing area of moderate size with limited access by road. Management controls are present with some dominant modifications.

(4) Roaded natural experiences occur in areas which have about equal probability of isolation and social contact. Challenge and risk are not often present. Some easily noticed dominant modifications occur, but management controls harmonize with the natural environment, with convenient access by road.

(5) Rural experiences occur in areas which have high probability for social interaction. Convenience is more important than challenge. Modifications are fairly constantly observed, controls are obvious and numerous, and access is designed for ease and comfort.

Vegetation management can enhance or impair these settings, and thus affect experiences. This evaluation groups forest users into workers and long-term residents, neighbors and newcomers, and visitors (table III-6).

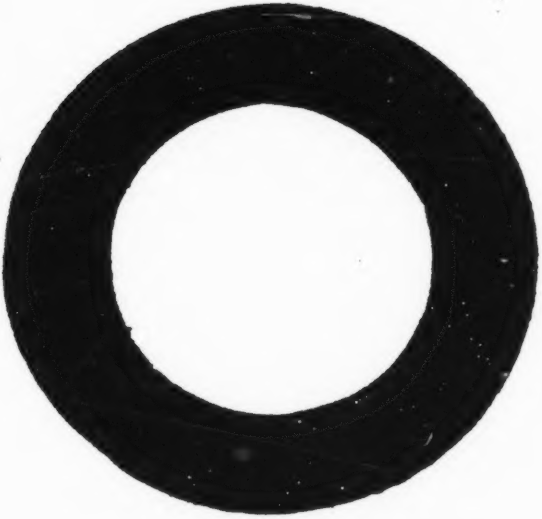
The table shows some possible experiences for each group in each setting. Many experiences can be obtained in any setting and individuals can be members of different user groups at different times. Workers include employees, contractors, permittees, and cooperators. Long-term residents are those people who have spent most of a lifetime in the area. Many are second and third generation residents. Neighbors include adjacent landowners, permittees, and local community residents. Newcomers are those people who have recently moved to the area, but nevertheless reside here. Visitors are those who come to the forests for specific purposes, stay a short while (hours or days), then return home.

Table III-6.--Experiences by user groups in different settings

	USERS		
SETTING	Workers/Long-Term Residents (Types of Work)	Neighbors/Newcomers (Types of Benefits)	Visitors (Types of Activities)
Primitive	Trail maintenance	Viewing, solitude, vicarious benefits	Hiking, nature study, fishing, canoeing, tent camping, solitude, walking
Semi-Primitive Non-Motorized	Resource inventory, inspections, limited resource work	Viewing, solitude, vicarious benefits	Hiking, nature study, fishing, hunting, camping, horseback riding, canoeing, swimming, solitude, walking
Semi-Primitive Motorized	Cultural treatments, resource manipulation, enforcement	Vehicular access, viewing, contact with others, vicarious benefits	Nature study, fishing, hunting, camping, pleasure driving, off-road vehicle use, boating, riding, gathering products
Roaded Natural	Cultural treatments, resource control enforcement, maintenance of services, wide range of intensity of work	Vehicular access, viewing, frequent contact with others. gathering products, vicarious benefits	Fishing, hunting, camping with services, pleasure driving, off-road vehicle use, boating, riding, gathering products games and play, interpretive services, cycling, picnicking
Rural	Resource control, resource marketing, transportation, economy, high intensity work	Rural comfort in proximity to urban services, viewing, recreation cabin use, contact with others dominates	Road tours, camping with full service and facilities, viewing man's works, boating, cycling, organized games, gathering products, picnicking

CHAPTER IV

Environmental Consequences



CHAPTER IV

ENVIRONMENTAL CONSEQUENCES

IN BRIEF Part A describes the purposes of this chapter and defines the types of environmental effects analyzed. Parts B through M present the analysis of effects on each environmental element, and part N summarizes these effects for each alternative. Parts O through Q identify research needs, energy requirements, and conflicts with others. Parts R through T disclose unavoidable adverse effects, irreversible and irretrievable resource commitments, and relationships between short-term uses and long-term productivity.

A. INTRODUCTION

This chapter discloses the effects of each alternative on each environmental element described in chapter III, and forms the scientific basis for mitigation measures and comparisons of alternatives in chapter II.

If done without clear guidelines and reasonable restrictions some vegetation management activities can damage our environment. Many potential problems, however, can be anticipated, so ways to prevent them or minimize their severity can be required in advance. Management requirements and mitigation measures (chapter II, part E) are the "do's" and don't's" that workers and managers must use to protect our environment as they perform vegetation management.

To clearly display them to the reader, effects of vegetation management are discussed separately for each environmetal element. Effects can be direct, indirect, or cumulative.

Direct effects occur at the same time and place as the actions that cause them. Their causes are usually obvious.

Indirect effects occur at a later time or different place than the actions that cause them. Their causes may not be obvious and may stem from effects on other environmental elements.

Cumulative effects are the combined effects of these actions with those of other past, present, and future actions. Cumulative effects can be on-site (confined to the project area) or off-site (outside the project area). Effects on vegetation, cultural resources, or soil are chiefly on-site. Effects on water and air quality or wildlife and fish are commonly off-site.

More precise definitions of these three effects are in 40 CFR 1508.

1. Scope of Analysis

The Southern Region includes a variety of landscapes, plant communities, soil types, and climatic conditions. In order to account for some of these gross differences, we divided the Region into three parts for analysis of vegetation management activities. This environmental impact statement addresses only the Ozark and Ouachita National Forests. See chapter III for a description of this area.

The area analyzed contains 2.7 million acres of national forests and has a complex variety of environmental conditions. We evaluate area-wide effects, and, where possible, sub-area effects. This approach is called "programmatic."

Within this broad area, site-specific vegetation management activities occur at hundreds of locations. Environmental effects from these projects vary with conditions on each project site. Many of these effects are predictable and are disclosed in this document. Other effects are unique to the site.

Recognizing this uniqueness, each project must be analyzed when proposed. The National Environmental Policy Act and Council on Environmental Quality Regulations describe a process called "tiering" to accomplish this evaluation. Tiering means the Forest Service will use and incorporate by reference any relevant information from this EIS and those done for Forest Land and Resource Management Plans when doing site-specific analyses for vegetation management projects.

Chapter II also describes environmental effects expected when different methods of vegetation management are used. Eight different ways (alternatives) to conduct the vegetation management program are evaluated. These approaches to doing work differ by:

1. Treating more or fewer acres either as a total or by individual methods.

2. Using or not using certain methods or tools.

3. Varying the intensity or frequency of application.

After reading about these effects and how they differ by alternative, the reader can refer back to chapter II, parts F, G, and H for comparison.

2. Herbicides Studied in This EIS

The risk assessment (appendix A) discloses human and wildlife health effects of 11 herbicides. Only fosamine, glyphosate, hexazinone, imazapyr, picloram, sulfometuron methyl, and triclopyr are being considered for use. 2,4-D, 2,4-DP, dicamba, and tebuthiuron) are not now used in the Ozark/Ouachita vegetation management program and are not projected for future use.

B. HUMAN HEALTH AND SAFETY

Discussion of human health and safety is presented in three parts:

1. Effects of herbicides. Herbicide effects on human health are evaluated in a risk assessment (appendix A) and are summarized in this section.

2. Effects of burning herbicidally-treated fuels. This section deals primarily with the analysis of risk to workers from herbicide residues present on fuels at the time of burning. Also included is an evaluation of risk from burning treated firewood.

3. Effects of other methods of vegetation management. This section deals with workers' risk of accident when using manual, mechanical, or biological methods or during prescribed burning.

Each section contains information about how the analyses were performed, including a summary of exposure routes and amount of exposure, associated inherent risk of each tool, and an assessment of the resultant risk of exposing people to that tool.

The evaluation of risk has two major facets -- risk assessment and risk management. In addition to following the formal risk assessment process, this EIS presents management requirements and mitigation measures to manage (reduce) risk (chapter II).

1. Effects of Herbicides

Source of Information

The human health risk assessment (appendix A) contains an analysis of the potential adverse effects to human health of 11 herbicides and 3 additives. The risk assessment was prepared by Labat-Anderson Inc. (LAI). Data from USDA Forest Service Agriculture Handbook #633 (Sassman and others 1984) and supplement (Sassman & Jacobs 1986) were updated based on more recent information provided to the Environmental Protection Agency (EPA) during the ongoing pesticide re-registration process. Background documents were prepared for light fuel oil (Weeks and others 1988a), imazapyr (Weeks and others 1988b), and mineral oil (Chin, Sczerzenie, and Haymore 1989). No data invalidated by EPA are used. A review of the toxic properties and environmental fate characteristics of mineral oil was prepared by LAI (Chin, Sczerzenie, and Haymore 1989; Supplement to Appendix A).

In addition to consultation with EPA, both LAI and the Vegetation Management Team exhaustively searched the scientific literature concerning health effects of herbicides. Inquiries were made of 21 library and toxicology data bases (DB) including: Medline, Toxline, Embase, Hazardous Substances DB, Registry of Toxic Effects of Chemical Substances DB, BIOSIS Previews, CAB (Commonwealth Agriculture Board) Abstracts DB, and Enviroline DB.

When available, only EPA validated data are used. Where unavailable (either required data not yet validated or data which is not required for registration) data from the open scientific literature were used. In two cases (inert ingredient data, and data concerning the dermal penetration rate of triclopyr), corporate proprietary data (inert ingredient data is confidential business data) or a pre-publication summary were used.

Four sections of the risk assessment (appendix A) apply to the analysis of human health effects:

- Section 2 describes methods currently used to apply herbicides in the Southern Region.
- Section 3 documents basic toxic properties of the chemicals (the hazard analysis).
- Section 4 documents probable exposures of workers and the public to these chemicals (the exposure analysis) by combining information from section 2 with estimates of hours worked and chemical use-rates.
- Section 5 combines predicted hazards and exposures to estimate the danger to workers and public (the risk assessment).

Hazard Identification

Human health effects are evaluated based on dose/time relationships. These relationships are expressed as:

Acute toxicity -- the potential of a chemical to cause adverse health effects when administered in a single dose.

Subchronic toxicity -- the potential of a small dose of herbicide or additive administered daily for a relatively short period of time (generally about 30 days) to cause adverse health effects.

Chronic toxicity -- the potential of a small dose of herbicide or additive administered daily over a long period of time to cause adverse health effects.

Herbicides available to consumers are formulated products which contain technical product (active ingredient) and other chemicals or water (inert ingredients). Testing to determine toxic properties is done in the laboratory. Most tests are done with active ingredients, not formulated products (the product as sold, including active and inert ingredients).

Some evaluated health effects related to toxicity are:

Mortality -- death of test animals, which suggests the possibility of human death. Herbicide or additive toxicity is determined by the amount of chemical that kills one-half of the animals tested. EPA categories of acute toxicity are very slightly toxic (large amounts of chemical are needed to kill an animal); slightly toxic; moderately toxic; and severely toxic (small amounts of chemical are needed to kill an animal) (appendix A, table 3-1).

Organ effects -- abnormal growth (size or shape) or observable malfunction of organs. Generally the liver, kidney, and other major organs are closely monitored.

Doses which cause organ effects are stated as amount of herbicide or additive per unit of body weight per unit of time (generally milligrams of chemical per kilogram of body weight per day).

Exposure and Dose Response

To understand the subsequent discussion, a distinction must must be made -- exposure and dose are NOT the same thing. Exposure is the amount of substance which an organism contacts in the environment. Dose is the amount of that substance which is taken into an organism (by breathing, eating, penetrating the skin, or any other route). Thus, dose can equal exposure, but normally it is much smaller.

In section 4 of the risk assessment, exposure levels of workers and the public are computed. Section 5 discusses the probable doses resulting from projected exposure levels. These levels cover the herbicides and additives proposed for use. Exposure estimates consider ways in which exposure occurs, such as specific public or worker activity, rate of herbicide application, size of treatment area, method of application, and physical characteristics of the chemical (persistence or drift potential). Dose is computed considering probable routes into the body (dermal penetration blood transport from lungs, etc.) at the projected exposure level.

Each exposure/dose projection is a series of possibilities running from no exposure/dose to some theoretical maximum for each factor. The number of combinations for seasonal timing, method of application, chemical, length of field day, number of field days per year per worker, etc. is incredibly large. To reduce the number of possible combinations, three specific exposure/dose scenarios are analyzed. Specific data are applied to each chemical and application method. These data approximate current and projected field activities (appendix A). The scenarios for which risk assessment is performed are:

> The **typical** situation estimates average dose resulting from exposure of workers and other people during routine operations.
>
> The **maximum** situation estimates the highest probable doses resulting from exposure of workers and other people when highest rates of chemical are applied by crew members who work a maximum number of hours per day for a maximum number of days per year. Maximum application rates used in Forest Service projects range from 1/20 (picloram) to 1/2 (imazapyr) labeled rates.
>
> An **accident** situation estimates dose resulting from exposure of workers and other people from direct exposure to herbicide resulting from a spill onto a worker or into a source of drinking water.

It is critical to remember that within each scenario ALL of the factors are relevant. The factors were mathematically modeled. Changing any factor changes the scenario and margin of safety projected for it. Risk is a function of dose -- but dose is critically dependent on several interrelated exposure factors and on toxicological properties of the chemical.

Potential movement of the herbicides and additives in the environment is estimated since this movement may also cause public exposure. Surface and subsurface movement (runoff and leaching) are estimated. Potential exposure due to drift of spray droplets is projected. Possible exposure as a result of either wildfire or deliberate burning (prescribed fire or firewood) is also predicted.

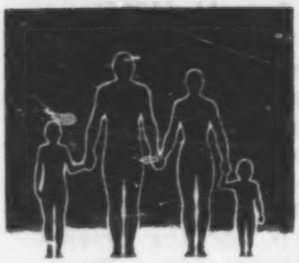
Exposure Information

Application rates and worker exposure times are based on actual projects and estimates of future use patterns in the Southern Region. Tables in the risk assessment show typical and maximum estimated hours per day and days per year a worker might be exposed, and typical and maximum amounts of chemical used per acre (tables 4-1 through 4-6, appendix A).

Estimates of public exposure are made for skin contact and consumption of food or water from forests treated with herbicides. Skin exposure is computed for visitors on-site and for off-site neighbors. People's dietary exposure is computed for consumption of contaminated water, fish, meat from wildlife or cattle, vegetables, and berries.

Separate exposure calculations are made for different herbicide application methods because each method has its own potential to expose workers to herbicides. For example, a mechanical sprayer delivering herbicide 15 feet from the

operator has far less likelihood of getting herbicide on the worker than does a sprayer held in the worker's hand. Also, **much less skin of a** properly clothed worker (as in the typical operation) is exposed than with a worker not properly dressed (as for maximum exposure). The only route of exposure considered significant for workers in the typical operation is through the skin; however, in the maximum situation inhalation is also significant.



Accident projections use reasonably foreseeable adverse impact assumptions:

- large amounts of skin are bare or directly exposed;
- a person is sprayed with the full per-acre rate of application on all exposed skin;
- a full backpack tank of spray solution covers the worker's skin and soaks the clothing which is worn for the entire workday;
- a full helicopter tank of herbicide (100 gallons diluted for application) is spilled into a reservoir;
- a 5-gallon container of undiluted herbicide is spilled into a small pond; and,
- additional exposure occurs in both water scenarios by drinking 1 liter of contaminated water.

Risk Description

Section 5 of the risk assessment converts exposure/dose data to project adverse health effects. The relationship between exposure and dose is influenced by the rate at which the chemical penetrates the skin (or is inhaled or ingested); how soon it is washed off; its potential to be broken down in the body; and how efficiently body systems eliminate it. Risk is directly related to dose and chemical toxicity.

EPA (1974, 1986b), the American Conference of Governmental Industrial Hygienists (1984), the National Agricultural Chemicals Association (1985), the National Research Council (1983, 1986), and others have published standards for acceptable levels of chemicals in the environment, in ground water, or on foods. This EIS makes no value judgments (acceptable/unacceptable, safe/unsafe). It compares predicted risk with published standards to see if the herbicide or additive is more risky or less risky than the standard. Additional protective measures which reduce predicted risk to a level less than the standard are noted as management requirements or mitigation measures in chapter II.

Three measures of risk are:

> **Margin of safety (MOS)** -- compares the NOEL (no observed effect level) for laboratory animals and the dose estimated for different application operations. The NOEL is the dose of a chemical which can be administered to test animals causing no visible effects

in subchronic testing. NOELS are evaluated for systemic (on the test animals) and reproductive (on their offspring) effects.

According to the National Research Council (1986) acceptable levels of risk for a herbicide can be estimated. A safety factor of 10 based on test animal data, is used to predict human effects (between species variation). An additional factor of 10 is used to account for possible variations among humans (within species variation). If the NOEL divided by the dose results in a number greater than 100, a chemical is considered to pose an acceptable risk for the general population (excluding sensitive individuals). The higher this margin of safety, the lower the risk of adverse health effects. For example, if the NOEL is 100 mg/kg/day, then all doses of less than or equal to 1 mg/kg/day have margins of safety of 100 or greater (poses less risk than the standard), while all doses greater than 1 mg/kg/day have less than a 100 fold MOS (poses a greater risk than permitted under the standard).

Mutagenic potential -- the possibility that the herbicide or additive will cause a change in the basic information-carrying structure (DNA) in the cell's nucleus. This is of special concern in reproduction where altered genetic information might be inherited by offspring.

Evaluation of mutagenic potential is difficult. For some herbicides, no EPA-validated mutagenicity tests exist, or tests are insufficient to allow scientific conclusions. When no validated tests are available mutagenicity is assumed, and cancer potency values are used to indicate the degree of mutagenicity. This represents the worst-case assumption.

Cancer potency -- an estimate of the possibility that a single exposure or a lifetime exposure to a herbicide or additive might cause cancer.

Data Gaps

Gaps exist in our knowledge. Incompleteness of data results from registration laws, age of data (tests performed in the past may be judged inadequate by current registration standards), and results from two or more tests which disagree. The Council on Environmental Quality regulations discuss the process for evaluating incomplete and unavailable information (40 CFR 1502.22(a) & (b)).

Data gaps which result in uncertainty about reasonably foreseeable significant adverse human health effects include the following:

1. Human toxicity data; moral restrictions and laws generally prohibit tests on human subjects. Animal tests are evaluated and mathematical models are used to project probable effects on humans, but human toxicity data are lacking.

2. Data on field worker exposure are available only for picloram, and triclopyr. Neither dermal penetration rates nor exposure estimates using current technology and mitigation are available for the other herbicides or additives evaluated.

3. Oncogenicity (the ability to cause either cancerous or non-cancerous tumors) data is unavailable for limonene, is incomplete for imazapyr, and has caused scientific disagreement for fosamine, glyphosate, light fuel oil, picloram and triclopyr (table 3-6, appendix A). Mutagenicity data are generally incomplete or inconclusive (table 3-5 and 3-6, appendix A).

4. The effects of smoke inhalation in forest fire settings is fairly well documented. However, knowledge of risk from burning fuels that have been treated with herbicides is incomplete.

5. Experimental information is not available on the public's exposure to herbicides applied using current methods.

6. Field studies on residue levels in plants or animals in and around treatment areas are lacking for several herbicides. Comparison of data is very difficult because existing studies use different analytical methods.

7. Data concerning the biochemistry and activity of breakdown products of herbicides formed by metabolic or environmental action is incomplete.

8. Information about synergistic effects of herbicide combinations with other herbicides and with inert ingredients is unavailable.

9. Data relating to cumulative effects are unavailable.

There have been recent changes about how to evaluate incomplete or unavailable data. The Council on Environmental Quality issued regulations in November 1978 (40 CFR 1502.22) which required that a worst case analysis be performed to estimate risk of relevant missing information. In 1986, they modified this requirement to include analysis of "... reasonably foreseeable significant adverse effects to the human environment ..." (40 CFR 1502.22).

Recognizing that there are significant incomplete or unavailable data, we have prepared a risk assessment (appendix A) using the 1986 requirements. In the risk assessment, we evaluate maximum and accident scenarios to meet the intent of 40 CFR 1502.22.

40 CFR 1502.22(b) requires that when costs for filling data gaps are exorbitant or, when means to obtain the data are unknown, the agency's evaluation of impacts must be based on theoretical approaches or research methods generally accepted in the scientific community. This analysis uses a risk assessment for missing data (appendix A). This approach which "is firmly based in scientific considerations... is a process of weighing alternatives and selecting the most appropriate actions" (National Research Council, 1983).

Although some of the data gaps are identified, an adequate data base was found to permit risk assessment of each of 14 herbicides and additives within NEPA guidelines. Throughout the analyses, conservative estimates (greatest risk to humans) were used to approximate missing or incomplete data. The risk assessment analyzes reasonably foreseeable maximum use and accident scenarios in which extreme exposure to herbicide occurs.

Each test needed to provide data which are currently unavailable or incomplete costs from tens of thousands (mutagenicity, worker exposure) to over a million dollars (chronic toxicity, oncogenicity). If all tests were performed, direct costs would be tens of millions of dollars. In addition, by delaying vegetation management indefinitely to complete testing, the public would suffer increased hazard from wildfire, and production of goods and services would be reduced (see analysis of the effects of Alternative A). The Forest Service considers that delay-caused fire hazard, delay-caused deterioration of services, and costs to fill these data gaps are too great to justify postponing issuance of this environmental impact statement.

Even if we ignore the magnitude of this potential investment, the inherent difficulty of analysis of human health effects remains. Studies on animals are modeled to approximate human health effects, but, especially for chronic effects, the relevance of 2 to 4-year studies on animals when compared with a 60 or more year life span for a human has been seriously questioned. However, the relevance of the concept of chronic exposure when applied to relatively non-persistent herbicides is questionable.

Acute Toxicity

Acute toxicity is the potential to cause death when the dose is by mouth (acute oral toxicity) or by skin (acute dermal toxicity) or other route. Estimates of acute human toxicity are based on acute toxicity values (single-dose mortality) determined for test animals in laboratory experiments using pure (technical grade) herbicides, generally administered one herbicide at a time.

The more toxic the product, the less is required to cause death. A dose of more than a pint (16 fluid ounce) of a very slightly toxic herbicide is required to cause the death of an average adult (150 pound) human. Similarly, between 1 fluid ounce and a pint of slightly toxic herbicide would kill an adult; between a teaspoonful (1/6 fluid ounce) and one fluid ounce of a moderately toxic herbicide is lethal; but, less than a teaspoonful of severely toxic herbicide or additive is required to cause death.

Acute oral toxicities of the chemicals are (appendix A, table 3-2):

- Very slightly toxic--Diesel oil, fosamine, imazapyr, kerosene, limonene, mineral oil, picloram, and sulfometuron methyl.
- Slightly toxic--Glyphosate, hexazinone, and triclopyr.
- Moderately toxic--None.
- Severely toxic--None.

Acute dermal toxicities are reported to be (appendix A, table 3-3):

- Very slightly toxic--Mineral oil.
- Slightly toxic--Diesel oil, glyphosate, hexazinone, imazapyr, kerosene (tentative), limonene (tentative), picloram, sulfometuron methyl, and triclopyr.
- Moderately toxic--Fosamine.
- Severely toxic--None.

Irritation

It is also necessary to know if a herbicide is an irritant: does it cause skin or eye problems? The risk assessment shows the amount of each chemical causing primary dermal or primary eye irritation. EPA (1974) categories are:

- IV- No irritation to the eyes; mild or slight skin irritation at 72 hours.
- III- No corneal opacity; moderate skin irritation at 72 hours.
- II- Corneal opacity reversible within 7 days; severe skin irritation at 72 hours.

- I- Irreversible corneal opacity at 7 days; corrosive to the skin.

Primary dermal irritations by the chemicals are (appendix A, table 3-3):

- Category IV--Fosamine, glyphosate, imazapyr, kerosene, limonene, mineral oil, picloram, and triclopyr.
- Category III--Hexazinone and sulfometuron methyl.
- Category II--Diesel oil.
- Category I--None.

Primary eye irritations by the chemicals are (appendix A, table 3-3):

- Category IV--Diesel oil, kerosene, and mineral oil.
- Category III--Glyphosate, imazapyr, picloram, and sulfometuron methyl.
- Category II--Hexazinone and triclopyr.
- Category I--None.
- No data--Fosamine and limonene.

No Observed Effect Levels

Systemic NOELs range from a low of 2.5 mg/kg for sulfometuron methyl and triclopyr to a high of 500 mg/kg for imazapyr; only sulfometuron methyl and triclopyr are less than 5 mg/kg (appendix A, table 3-2). Reproductive NOELs are reported between 2.5 mg/kg (dicamba and triclopyr) and 751 mg/kg (light fuel oils) (appendix A, table 3-2). Systemic NOEL of mineral oil is 2 ml/kg (HDT, appendix 1, Risk Assessment. Additionally, class 5 mineral oil is approved by the FDA for use as a direct multi-purpose food additive (21 CFR, Part 172.878) and for use in animal feed (21 CFR, Part 573.680) subject to provisions in the sub-parts.

Effects of Inert Ingredients

An inert ingredient is not necessarily chemically unreactive; it is simply not the active ingredient in the formulation. EPA's Office of Pesticide Programs (EPA 1987) has identified about 1,200 inert ingredients currently used in pesticides, and they have categorized these chemicals based on their ability to cause chronic human health effects as follows:

- List 1--Inerts of toxicological concern: approximately 50 chemicals shown to be carcinogens, developmental toxicants, neurotoxins, or potential ecological hazards which merit highest priority for regulatory action.

- List 2--Potentially toxic inerts: about 50 chemicals with toxicity data suggesting, but not confirming, possible chronic health effects or having chemical structures similar to chemicals on list 1. They are high priority for testing.

- List 3--Inerts of unknown toxicity: approximately 800 chemicals were placed here "... if there was no basis for listing it on any of the other three lists." Priority for further testing is low.

- List 4--Inerts of minimal concern: about 300 chemicals generally regarded as innocuous. Priority for testing is low.

Inert ingredient information is presented in the risk assessment (appendix A, table 3-8). None of the chemicals evaluated is on List 1 and only one chemical (kerosene) is on List 2. One additive is unclassified and the remaining inert substances are on list 3 or 4. In all cases, formulated products (the products as purchased which include both active and inert ingredients) have lower risk of acute toxic effects than the active ingredient alone (appendix A). Mineral oil in class 4 or class 5, if used as an inert ingredient to replace kerosene, is a list 4 inert.

Current Forest Service policy is to permit use of formulations containing List 3 or List 4 inerts. Formulations containing List 2 chemicals are used only when no formulation with only List 3 or List 4 inert ingredients are available meet project objectives, and only after an evaluation of the inert ingredient shows that health risks are acceptable. Formulations containing List 1 inerts are not used.

Exposure Levels

Tables 4-25 through 4-40 in the risk assessment display projected public, worker and accident exposure levels. Important reference points are discussed below.

Berry pickers exposed to 0.14 mg/kg/day fosamine in the maximum exposure scenario represent the highest projected level of public exposure. Lowest projected exposure levels are 0.00001 mg/kg/day for public dermal exposure to drift of picloram and sulfometuron methyl, and less than .00001 mg/kg/day for public dietary exposure to imazapyr (via fish), limonene (fish), picloram (fish), and sulfometuron methyl (water, fish, or meat) when these chemicals are applied at typical rates. Many worker exposure levels in the maximum scenario are greater than 1 mg/kg/day (a very high level of exposure). Maximum scenario exposures range from 1.5 to 100 or more times as great as typical exposure levels. For workers in normal settings, both typical and maximum scenarios show the mixer/loader and the backpack (broadcast foliar) applicator have the greatest exposure.

Accidental spills involving workers cause the greatest individual exposure. The range is from 1020 mg/kg/day for diesel oil to 29.7 mg/kg/day for triclopyr. No other accident scenario (accidental spray, or spill into water) for any other chemical shows greater than 0.5 mg/kg/day exposure.

Typical Public Scenario

Tables IV-1 through IV-5 display human margin of safety data. These tables summarize data presented in tables 5-8 through 5-23 of appendix A (risk assessment).

Comparison of estimated MOS's for *typical* public exposures (table IV-1) indicates that no member of the public, including sensitive individuals, should be affected by herbicides or additives proposed for use in Region 8. This generalization applies to systemic and reproductive effects.

Maximum Public Scenario

For the *maximum* public exposure scenario (table IV-2) only berry pickers who eat about 1 lb unwashed, contaminated berries are at risk. Systemic MOS's are greater than 100 for all chemicals used in this scenario except for triclopyr (amine and ester). For the reproductive MOS's, only berry pickers/eaters are at risk and only in areas where fruiting plants have been treated with triclopyr (amine and ester) which has MOS of less than 100. Berries sprayed with this product should not be eaten.

No public exposure for either the typical or maximum aerial application scenario has a MOS less than the 100-fold criterion other than in the case of eating foraged berries as already discussed.

Typical Worker Scenario

None of the chemicals being evaluated for use on the Ozark-St. Francis and Ouachita National Forests have margins of safety of less than 100 in the typical evaluation scenario in either systemic or reproductive MOS evaluations. Four systemic MOS's are at or very close to a MOS of 100; diesel oil used for foliar spray applied manually (100), diesel oil used in the ground mechanical scenario has an MOS of 120 for both the mixer/loader and for the mixer/loader/applicator, and fosamine applied manually for foliar spray also has an MOS of 120. No other scenarios show less than a MOS of 175 for either measure (systemic or reproductive).

The seven herbicides and four additives evaluated for use in the Ouachita/Ozark area are considered to pose low risk which requires no mitigation in addition to that considered in our evaluation and required in chapter II.

Maximum Worker Scenario

For workers applying herbicides in the *maximum* exposure scenario (table IV-4), several chemicals are of concern. Systemic MOS's for diesel oil, fosamine, glyphosate, hexazinone, kerosene, and triclopyr (amine and ester) all

Table IV-1.—Public risk in the typical scenario; systemic and reproductive MOS values are used to compare risk levels

SYSTEMIC MOS

										TRICLOPYR	
	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	AMINE	ESTER
Dermal											
Drift	I	I	I	I	I	I	I	I	I	I	I
Onsite	I	I	I	I	I	I	I	I	I	I	I
Dietary											
Water	I	I	I	I	I	I	I	I	I	I	I
Fish	I	I	I	I	I	I	I	I	I	I	I
Meat	I	I	I	I	I	I	I	I	I	I	I
Vegetable	I	I	I	I	I	I	I	I	I	I	I
Berry pickers	I	I	I	I	I	I	I	I	I	I	I
Based on a systemic NOEL of:											
(mg./kg.)	7.38	25	31	10	500	28	227	7	2.5	2.5	2.5

REPRODUCTIVE MOS

										TRICLOPYR	
	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	AMINE	ESTER
Dermal											
Drift	I	I	I	I	I	I	I	I	I	I	I
Onsite	I	I	I	I	I	I	I	I	I	I	I
Dietary											
Water	I	I	I	I	I	I	I	I	I	I	I
Fish	I	I	I	I	I	I	I	I	I	I	I
Meat	I	I	I	I	I	I	I	I	I	I	I
Vegetable	I	I	I	I	I	I	I	I	I	I	I
Foraged berries	I	I	I	I	I	I	I	I	I	I	I
Based on reproductive NOEL of:											
(mg./kg.)	751	500	10	50	300	751	227	50	25	2.5	2.5

KEY: I = insignificant risk (MOS exceeds 1000); LO = Low risk (MOS is between 100 and 1000); HI = High risk (MOS is between 1 and 100); VH = Very high risk (MOS is less than 1); N = Not applicable

NOTE: Chemical names are abbreviated in tables IV-HH1 through IV-HH5 as follows: DICAM = dicamba, DIES = diesel oil, FOSAM = fosamine, GLYPH = glyphosate, HEXAZ = hexazinone, IMAZA = imazapyr, KEROS = kerosene, LIMON = limonene, PICLO = picloram, SULFO = sulfometuron methyl, and TEBUT = tebuthuron.

Table IV-2.—Public risk in the maximum scenario; systemic and reproductive MOS values are used to compare risk levels

SYSTEMIC MOS										TRICLOPYR	
	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	AMINE	ESTER
Public											
Dermal											
Drift	I	I	I	I	I	I	I	I	I	I	I
Onsite	I	I	I	I	I	I	I	I	I	I	I
Dietary											
Water	I	I	I	I	I	I	I	I	I	I	I
Fish	I	I	I	I	I	I	I	I	I	I	I
Meat	LO	I	I	I	I	I	I	I	I	LO	LO
Vegetable	I	I	I	I	I	I	I	I	I	I	I
Berry pickers	LO	LO	LO	LO	I	LO	I	LO	LO	HI	HI
Based on a systemic NOEL of: (mg./kg.)	7.38	25	31	10	500	28	227	7	2.5	2.5	2.5

REPRODUCTIVE MOS										TRICLOPYR	
	DIESE	FOSAM	GLYPH	HEXA	IMAZA	KEROS	LIMON	PICLO	SULFO	AMINE	ESTER
Public											
Dermal											
Drift	I	I	I	I	I	I	I	I	I	I	I
Onsite	I	I	I	I	I	I	I	I	I	I	I
Dietary											
Water	I	I	I	I	I	I	I	I	I	I	I
Fish	I	I	I	I	I	I	I	I	I	I	I
Meat	I	I	I	I	I	I	I	I	I	LO	LO
Vegetable	I	I	I	I	I	I	I	I	I	I	I
Foraged berries	I	I	LO	LO	I	I	I	I	I	HI	HI
Based on reproductive NOEL of: (mg./kg.)	751	500	10	50	300	751	227	50	25	2.5	2.5

KEY: I = Insignificant risk (MOS exceeds 1000); LO = Low risk (MOS is between 100 and 1000); HI = High risk (MOS is between 1 and 100); VH = Very high risk (MOS is less than 1); N = Not applicable

Table IV-3.—Worker risk in the typical scenario; systemic and reproductive MOS values are used to compare risk levels

SYSTEMIC MOS	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TRICLOPYR AMINE	 ESTER
Aerial											
Pilot	I	LO	I	I	I	I	I	I	I	LO	I
Mixer/loader	LO	LO	I	LO	I	LO	I	I	I	LO	LO
Observer	I	I	I	I	I	I	I	I	I	I	I
Mechanical ground											
Applicator	LO	I	I	I	I	I	I	I	I	LO	LO
Mixer/loader	LO	I	I	LO	I	LO	I	I	I	LO	LO
Appl/Mix/Load	LO	I	I	LO	I	LO	I	I	I	LO	LO
Manual ground											
Backpack spray	N	LO	LO	LO	I	LO	I	I	LO	LO	LO
Basal stem	LO	N	N	N	N	I	I	N	N	N	LO
Soil spot	N	N	N	LO	N	N	N	N	N	N	N
Cut surface	N	N	LO	N	I	N	N	I	N	LO	N
Based on a systemic NOEL of: (mg./kg.)	7.38	25	31	10	500	28	227	7	2.5	2.5	2.5

REPRODUCTIVE MOS	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TRICLOPYR AMINE	 ESTER
Aerial											
Pilot	I	I	I	I	I	I	I	I	I	LO	I
Mixer/loader	I	I	I	I	I	I	I	I	I	LO	LO
Observer	I	I	I	I	I	I	I	I	I	I	I
Mechanical ground											
Applicator	I	I	I	I	I	I	I	I	I	LO	LO
Mixer/loader	I	I	I	I	I	I	I	I	I	LO	LO
Appl/Mix/Load	I	I	I	I	I	I	I	I	I	LO	LO
Manual ground											
Backpack spray	N	I	LO	I	I	I	I	I	I	LO	LO
Basal stem	I	N	N	N	N	I	I	N	N	N	LO
Soil spot	N	N	N	I	N	N	N	N	N	N	N
Cut surface	N	N	LO	N	I	N	N	I	N	LO	N
Based on reproductive NOEL of: (mg./kg.)	751	500	10	50	300	751	227	50	25	2.5	2.5

KEY: I = Insignificant risk (MOS exceeds 1000); LO = Low risk (MOS is between 100 and 1000); ■ = High risk (MOS is between 1 and 100); VH = Very high risk (MOS is less than 1); N = Not Applicable

Table IV-4.—Worker risk in the maximum scenario; systemic and reproductive MOS values are used to compare risk levels

SYSTEMIC MOS	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TRICLOPYR AMINE	TRICLOPYR ESTER
Aerial											
Pilot	LO	LO	LO	LO	I	LO	I	I	LO	LO	[illegible]
Mixer/loader	LO	HI	LO	LO	I	HI	I	I	LO	HI	HI
Observer	I	I	I	I	I	I	I	I	I	I	I
Mechanical ground											
Applicator	[illegible]	[illegible]	[illegible]	[illegible]	I	HI	LO	I	LO	[illegible]	[illegible]
Mixer/loader	HI	HI	HI	HI	I	HI	LO	I	LO	HI	HI
Appl/Mix/Load	HI	HI	HI	HI	I	HI	LO	I	LO	HI	HI
Manual ground											
Backpack spray	N	HI	[illegible]	HI	I	HI	LO	I	HI	[illegible]	[illegible]
Basal stem	HI	N	N	N	N	LO	I	N	N	N	LO
Soil spot	N	N	N	LO	N	N	N	N	N	N	N
Cut surface	N	N	LO	N	I	N	N	I	N	LO	N
Based on a systemic NOEL of: (mg./kg.)	7.38	25	31	10	500	28	227	7	2.5	2.5	2.5

REPRODUCTIVE MOS	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TRICLOPYR AMINE	TRICLOPYR ESTER
Aerial											
Pilot	I	I	LO	LO	I	I	I	I	I	LO	HI
Mixer/loader	I	I	HI	LO	I	I	I	I	I	HI	HI
Observer	I	I	I	I	I	I	I	I	I	I	I
Mechanical ground											
Applicator	I	I	HI	HI	I	LO	LO	I	I	HI	HI
Mixer/loader	I	I	HI	HI	I	LO	LO	I	I	HI	HI
Appl/Mix/Load	I	I	HI	HI	LO	LO	LO	I	I	HI	HI
Manual ground											
Backpack spray	N	LO	HI	HI	LO	LO	LO	I	LO	[illegible]	[illegible]
Basal stem	I	N	N	N	N	I	I	N	N	N	LO
Soil spot	N	N	N	I	N	N	N	N	N	N	N
Cut surface	N	N	HI	N	I	N	N	I	N	LO	N
Based on reproductive NOEL of: (mg./kg.)	751	500	10	50	300	751	227	50	25	2.5	2.5

KEY: I = Insignificant risk (MOS exceeds 1000); LO = Low risk (MOS is between 100 and 1000); ▨ = High risk (MOS is between 1 and 100); VH = Very high risk (MOS is less than 1); N = Not applicable

Table IV-5.—Human risk in the accident scenario; systemic and reproductive MOS values are used to compare risk levels

SYSTEMIC MOS

	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TRICLOPYR AMINE	TRICLOPYR ESTER
Spill onto worker	VH	VH	VH	VH	HI	VH	VH	HI	VH	VH	VH
Accidental spray	HI	HI	LO	HI	I	HI	I	I	LO	HI	HI
Spill into water											
Ground	LO	LO	I	LO	I	I	I	I	HI	[illegible]	[illegible]
Air	I	I	I	I	I	I	I	I	I	LO	LO
Based on a systemic NOEL of: (mg./kg.)	7.38	25	31	10	500	28	227	7	2.5	2.5	2.5

REPRODUCTIVE MOS

	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TRICLOPYR AMINE	TRICLOPYR ESTER
Spill onto worker	VH	HI	VH	VH	HI	HI	VH	LO	VH	VH	VH
Accidental spray	I	LO	HI	LO	I	I	I	I	I	HI	HI
Spill into water											
Ground	I	I	LO	I	I	I	I	I	LO	[illegible]	[illegible]
Air	I	I	I	I	I	I	I	I	I	LO	LO
Based on reproductive NOEL of: (mg./kg.)	751	500	10	50	300	751	227	50	25	2.5	2.5

Ground spill is assumed to be 5 gal into a pond; air spill is assumed to be 100 gal into a reservoir.

KEY: I = Insignificant risk (MOS exceeds 1000); LO = Low risk (MOS is between 100 and 1000); HI = High risk (MOS is between 1 and 100); VH = Very high risk (MOS is less than 1); N = Not applicable

have at least one worker exposure which failed to exceed an MOS of 100. Reproductive MOS's also fail to exceed 100 for some glyphosate, hexazinone, and triclopyr application methods. Remember that maximum scenarios are based on assumptions that, acting together, greatly magnify the estimate of risk (appendix A).

Accident Scenario

In the accident scenario several exposures are of concern (table IV-5). For systemic effects, all spills directly onto workers who did not immediately wash had either high (MOS between 1 and 100) or very high (MOS less than 1) risk levels. When a person (worker or member of the public) is accidentally sprayed during either aerial or ground spray projects, diesel, fosamine, hexazinone, kerosene, and triclopyr have MOS's of less than 100. MOS's for a ground spill (5 gallons into a pond) of sulfomturon methyl and triclopyr (amine and ester) are less than 100 (greater risk than the standard). All MOS's projected for aerial spills are greater than 100 (less risk than the standard).

For reproductive effects, all spills onto workers have MOS's below 100 except for picloram. For spills into water, only triclopyr (amine or ester) has a MOS of less than 100.

Herbicide Oncogenicity

An analysis of maximum cancer risk was performed for light fuel oils (diesel and kerosene) which contain small amounts of materials known or suspected of causing cancer; and for glyphosate and picloram for which there is scientific uncertainty about its ability to cause cancer. Cancer risk assessment was not performed for mineral oils (class 4 mildly hydrotreated and class 5 white oils and petrolatums) which show no evidence of carcinogenicity. Inadequate data were found to evaluate the severely hydrotreated oils in class 4. Evidence does exist indicating carcinogenicity of less refined oils.

Data relating to fosamine, triclopyr, and limonene are unavailable, and imazapyr's data are incomplete. There is no evidence to show that any of the other chemicals could cause cancer: all have studies showing no effect (appendix A).

Computation of lifetime cancer risk to the public from the four relevant chemicals evaluated (table IV-6 and appendix A, table 5-26) showed no risk greater than 2.0 in 1,000,000,000. Compare this with the values presented in table 5-28 of the risk assessment. The worst risk estimated for any of these chemicals is only 1/10,000th the risk of getting cancer from exposure to a single x-ray.

Lifetime cancer risk to workers (table IV-6 and appendix A, table 5-26) is less than 7.2 in 10,000,000 (fewer than 8 in 10 million workers are expected to get cancer).

Table IV-6.--Lifetime cancer risk

	DIESE	GLYPH	KEROS	PICLO
Public				
Dermal				
Drift	L	L	L	L
Onsite	L	L	L	L
Dietary				
Water	L	L	L	L
Fish	L	L	L	L
Meat	L	L	L	L
Vegetable	L	L	L	L
Berry pickers	L	L	L	L
Workers				
Aerial				
Pilot	L	L	L	L
Mixer/loader	L	L	L	L
Observer	L	L	L	L
Mechanical ground				
Applicator	L	L	L	L
Mixer/loader	L	L	L	L
Appl/Mix/Load	L	L	L	L
Manual ground				
Backpack	NA	L	L	L
Basal stem	L	NA	L	NA
Soil spot	NA	NA	NA	NA
Cut surface	NA	L	NA	L

KEY: ■ = Risk greater than 1 in a million; L = Risk less than 1 in a million; NA = Not Applicable

Mutagenicity

Glyphosate, imazapyr, mineral oil (class 5), and sulfometuron methyl have tested negative for mutagenicity. Hexazinone and triclopyr are nonmutagenic in the majority of assays and pose slight to negligible mutagenic risk. Fosamine presents a very slight risk of causing mutagenic effects. No mutagenicity testing has been updated by EPA for limonene. The Food and Drug Administration, however, reports that it is "generally regarded safe" as a food additive (appendix A and table 3-6).

Diesel oil and kerosene have shown mixed mutagenicity test results. Both contain small amounts of the carcinogenic compounds benzene and benzo(a)pyrene. Weeks and others (1988a) report that these compounds have the same low-order risk of causing heritable mutation as is reported for their cancer potency.

Bioaccumulation

Bioaccumulation is the process whereby a chemical is concentrated in tissue at a level greater than in the environment (Ottoboni 1984). To bioaccumulate a chemical must be absorbed into the body at a rate greater than it is eliminated (either through chemical breakdown or via excretion). Temporary storage in cells is not bioaccumulation. Bioaccumulation is a dynamic equilibrium process; it is not instantaneous but requires that the body be allowed time to come to an equilibrium and later to improve on that equilibrium. Bioaccumulation can occur only when the body fails to eliminate a substance.

Table 3-4 in the risk assessment shows elimination rates reported for six relevant chemicals: fosamine, glyphosate, hexazinone, imazapyr, picloram, and triclopyr. Elimination rates for diesel oil, kerosene, limonene, mineral oil, and sulfometuron methyl are not available at present. Elimination varied from 100 percent fosamine [rat/72 hours], and hexazinone [rat/72 hours] to a low of only 83 percent (triclopyr/rat/time not specified). Some herbicide had not been eliminated at termination of the study for: glyphosate (8 percent/rabbit/5 days), imazapyr (13 percent/rat/24 hours), picloram (10 percent/dog/48 hours and 4 percent/unspecified test animal/24 hours), and triclopyr (9-17 percent/rat/unspecified time). The most rapid elimination reported is for hexazinone (93 percent/rat/2 hours).

It is unclear from the studies if these amounts of not-eliminated material represent the lowest expected level at which equilibrium is established or if further elimination continued after the termination of the studies. Classic concepts of chemical half-life in the organism and bioaccumulation as permanent storage conflict and the controversy is unresolved. Bioaccumulation, in the popular sense of continuous addition of new chemicals to an overwhelming burden, does not appear to occur with these herbicides. The bodies of test animals responded to exposure by eliminating the herbicides, not by permanently adding them to a previously accumulated stockpile of other chemicals. The limited number of exposure studies performed on field workers support this conclusion when applied to humans (appendix A).

Synergism

Synergistic effects of chemicals are effects which occur from exposure to two or more chemicals either simultaneously or within a relatively short period. To be considered synergistic an effect must be greater than the sum of the effects of each agent alone.

The herbicide mixtures evaluated for the Southern Region's vegetation management program have not shown synergistic effects in humans who have used them in other applications.

Toxic effects of possible herbicide combinations other than those commercial mixtures registered by EPA have not been studied. Time and money normally limit toxicity testing to the highest priority -- evaluation of toxic effects of each chemical alone. Based on the limited amount of data available about effects of herbicide combinations, it is very unlikely that toxicologically significant synergistic effects could occur from exposure to two or more of the chemicals evaluated (appendix A).

There are several reasons which make the probability of the occurrence of synergism involving the evaluated herbicides extremely small. Herbicide residue in plants and soil does not persist from application to application. This results from the relatively short persistence and infrequent usage of herbicides on each site. These herbicides herbicides are rapidly excreted from the body. Exposure to two or more chemicals at the same time is likely only in cases where those chemicals are combined in a single spray mixture. Workers having frequent contact with different herbicides are exposed to some risk of synergism. Public exposure to forestry herbicides is minimal and extremely infrequent.

The Environmental Protection Agency's guidelines for the health risk assessment of chemical mixtures (EPA 1986a) reflect the problem of missing and unavailable data with respect to synergism. While not recommending any specific process for risk assessment, they do consistently explain the use of additive models which do not recognize possible effects greater than those caused by the known effects of the chemicals in the mixture.

2. Effects of Prescribed Fire

Brown-and-Burn

Brown-and-burn combines the use of herbicides and fire. Herbicide is applied, vegetation is allowed to dry for 30 to 100 or more days, and then prescribed fire is used to reduce the above-ground fuel load and open the site for reforestation.

Because of concerns about the effect burning herbicide-treated vegetation might have on the health of the public and workers, two brown-and-burn scenarios are evaluated in the risk assessment (appendix A). This analysis has two purposes; to determine a sufficient interval to ensure that worker and public risk is low, and to evaluate the potential health risk resulting from wildfire occurring immediately after herbicide application.

Fuel load, smoke density, and amount of fuel consumed are based on Southern Region data for representative fuel types. Published degradation rates are used to estimate the amount of herbicide remaining intact at the time of fire. Maximum exposures are calculated for a wildfire occurring on the day of treatment.

Several assumptions were necessary due to missing or incomplete data. In all cases, assumptions were made in a conservative manner (maximum reasonable risk was chosen over lesser risk) causing estimates of risk to be high. This increases the margin of safety for workers and the public.

Threshold limit values (TLV) published by the American Conference of Governmental Industrial Hygienists (1984) are used as an indicator of the lowest acceptable level of risk from herbicide residue in smoke. TLV values indicate an acceptable level of workers' daily exposure (8 hours per day) to airborne chemicals over their careers.

Even in the wildfire scenario (wildfire occurs the same day as application) the worst exposure projected is 46 times less than the TLV. All herbicide/application-method brown-and-burn combinations evaluated after 30 days (minimum vegetation curing time period) are estimated to have significantly less risk than the TLVs allow. Seventy-four times less exposure than the TLV is the closest any typical herbicide/method combination came to the TLV. Based on this comparison there is negligible risk of negative health effects from herbicide used in brown-and-burn operations.

Bush and others (1987) measured residues released from burning herbicide-treated wood (in wood stoves or fireplaces). The relevant herbicide evaluated were picloram and triclopyr. Evaluation was made 4, 8, and 12 months after treatment. Residues under rapid combustion were generally much less than under slow combustion. They found that more than 95 percent of the tested herbicides were broken down by the heat of a well developed (800-1,000°C) fire. These concentrations are much less than the maximum exposure concentrations estimated for these herbicides in brown-and-burn operations (appendix A, table 5-24). Thus no significant potential exists for negative human health effects from the burning (in a hot fire) of firewood treated with these herbicides.

Recent information by McMahon (1989) further suggests that brown-and-burn poses little additional risk to workers than prescribed burning untreated fuels. Worker monitoring using air samplers worn during fire fighting activities detected no significant parent herbicide residue in 12 fires. Label rates of hexazinone, imazapyr, picloram, or triclopyr had been used to pretreat fuels on all sites. Detection level of the samplers was 1 mg/m^3 and workers on the fires were exposed to 350 to 4,000 mg/m3 of particulate matter for between 1 and 5 hours.

3. Effects of Other Methods (General)

People are concerned about worker health and safety for all methods used in vegetation management.

Sources of Information

Although extensive accident reporting systems exist (U.S. Department of Health and Human Services, Office of Workman's Compensation, and insurance companies), forestry-related activities cannot be isolated from data recorded in these systems. Additionally, national summaries of accidents (U.S. Department of Labor, Bureau of Labor Statistics and others) report only numbers of accidents. Therefore, data are taken directly from Southern Region accident reports. Four years of accident reports are analyzed. A total of 1,063 accidents involving field personnel requiring the care of a doctor were reported during fiscal years 1984-1988. Of the 1,063 field accidents regionwide, 209 are directly related to vegetation management. The 44 Ozark/Ouachita Mountain forest accidents directly related to vegetation management are the basis for subsequent discussion.

Accident Frequency

Accidents have been reported from use of manual and prescribed burning methods. No accidents have been reported from mechanical or biological methods. The only reported herbicide-related accidents were; a worker who slipped while carrying a backpack unit and twisted his ankle and a worker with skin rash from being accidently caught in drift while applying an aquatic herbicide in a lake.

There were no vegetation management-related fatalities during the 5-year period for which detailed accident records are available. Fatality records are maintained for a longer period of time, and during the period 1976 - 1985, two tree felling deaths and two fire-related deaths were related to vegetation management.

No data exist to determine occurrence rates of other health problems. Such things as loss of hearing due to loud tools, cancers resulting from inhaling fumes from gasoline engines or gasoline contacting skin, and secondary infection of a wound from vegetation management are not reported in a way which allows analysis. All could occur, but frequency of occurrence is unknown.

Frequency of accidents by body part affected are presented in table IV-7. In table IV-8, frequency of accidents as a function of the activity being performed is displayed. Figure IV-1 shows the number of accidents expected during a 25-year career. Overall, traumatic injuries to the back, hand and skin predominate.

Based on tables IV-7 and IV-8, and figure IV-1, vegetation management activities rank as follows (most to least risky):

1. Range management
2. Trail and recreation site maintenance
3. Road maintenance
4. Prescribed burning
5. Site preparation work
6. Wildlife habitat management

High risks include: A 55 in 100 risk of hand, finger, or wrist injury (an accident more frequently than once every 2 years) and a 35 in 100 risk of a head injury (one accident each 3 years) for full time range workers; a 16 in 100 risk of leg injury to workers doing prescribed burning; an 11 in 100 chance of back injury to full time roadside maintenance crew members; and, an 8 in 100 risk of eye injury to full time prescribed burners (an average of two accidents in a 25 year career).

Severity Rating

Severity rating is based on reported costs: low ($1 - $100), moderate ($100 - $500), and high (over $500). Severity of accidents related to site preparation is notable; 5 in 39 are in the severe category; 14 in 39 are moderately severe; and only slightly more than half are low severity accidents. Overall the ratios of low:moderate:severe accidents are similar between activities.

Table 5-28 of appendix A displays the risk of cancer or death resulting from several routine activities. Vegetation management activities contain more risk of accidental injury than these routine activities, though the consequences are normally less severe than death.

Figure IV-2 shows the average worker's risk of having an accident in a 25-year career. After correcting for the relative amounts of time spent in each activity, activities are rated (most to least risk): site preparation, road right-of-way maintenance, recreation and trails maintenance, wildlife habitat management, prescribed fire, and range habitat maintenance (figure IV-2).

Table IV-7.--Body part affected: Average number of accidents per man year (40% field work) worked in several vegetation management activities in Ozark/Ouachita Mountain forests; Region 8, FY'84-FY'88

	Site Prep	Pres Burn	Range	Wildlife	Road Maintenance	Trails & Recreation Maintenance
Head, Neck, Ear, Nose	0.002		0.140		0.022	
Eye	0.006	0.031		0.009	0.022	0.026
Skin	0.008				0.022	
Arm	0.004					
Wrist, Hand Finger	0.006		0.218			0.026
Back, Chest, Abdomen	0.013				0.043	
Legs	0.006	0.062		0.009		0.051
Ankle, Foot, Toes	0.004			0.009	0.022	0.026
Other						
Total by Activity	0.048	0.093	0.218	0.028	0.129	0.129

Blank cells = no accidents reported during the three years being investigated.

Table IV-8.--Cause of injury: Average number of accidents per man year (40% field work) worked in several vegetation management activities in Ozark/Ouachita Mountain forests; Region 8, FY'84-FY'88

	Site Prep	Pres Burn	Range	Wildlife	Road Maintenance	Trails & Recreation Maintenance
Insects	0.004					
Fire						
Hand tools	0.010		0.019			0.026
Power tools Chain saw	0.004					
Power tools Other					0.022	
Struck by Vegetation	0.008				0.022	
Slipping	0.010	0.062	0.109	0.009	0.043	0.051
Lifting	0.008					
Dust & Debris	0.002	0.031		0.009	0.022	
Poisonous plants	0.002			0.009	0.022	
Pesticides	0.002					
Other						
Total by Activity	0.048	0.093	0.218	0.028	0.129	0.129

Blank cells = no accidents reported during the three years being investigated.

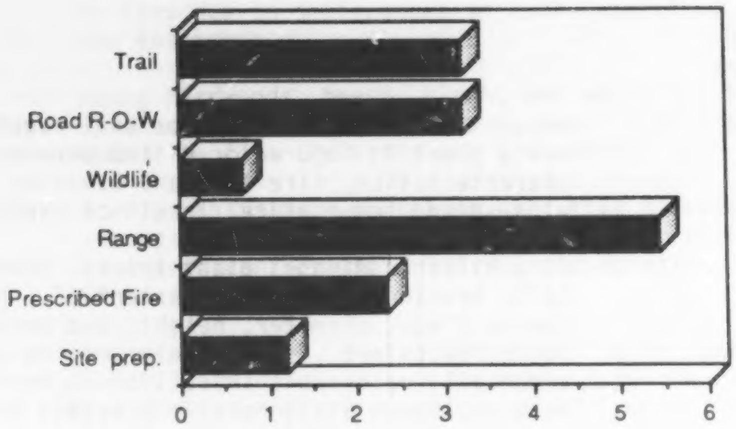


Figure IV-1.--Expected number of accidents per person during a 25-year (40% field work) career performing a single vegetation management activity on an Ozark/Ouachita Mountain forest.

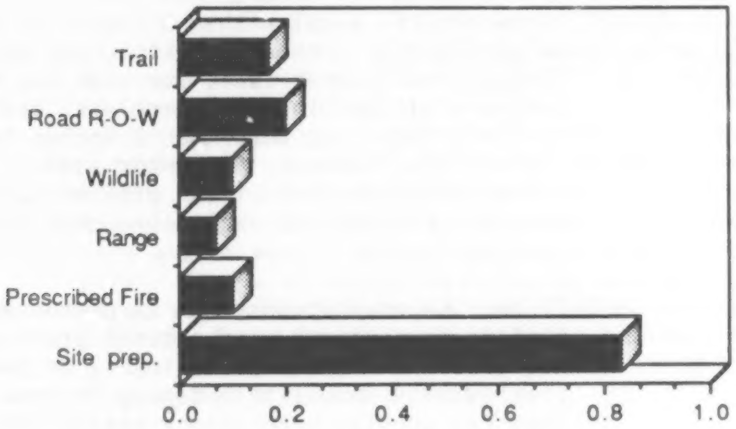


Figure IV-2.--Average number of accidents suffered by a worker working for 25 years (40% field work) in a vegetation management job with activity proportional to the average work program for Ozark/Ouachita Mountain forests.

C. VEGETATION

1. Effects of Prescribed Fire

Injury and Mortality

Prescribed fire can injure or kill vegetation. Whether or not a plant is injured or killed depends upon plant characteristics, fire type and behavior, topography, wind speed, temperature, length of exposure, and season.

Fire kills or damages plant leaves, needles, buds, stems, bark, branches, or roots. Extent of injury depends on species, age, diameter, height, and protective adaptations. Young, succulent, and actively growing vegetation is especially vulnerable (Hare 1961; Loomis 1973). For this reason, losses are generally greatest for seedlings or sprouts of any species.

Hardwood species are generally much less resistant to fire damage than are pine species (Wade 1983). In a literature review by Fennell and Hutnik (1970), that emphasized hardwood forests of eastern North America, several studies determined that within a size class yellow poplar is more resistant to fire damage than oaks. Among oak species that occur in the Ozark/Ouachita area, white oak is the most resistant to fire damage followed by red oak and black oak. Hickory, red maple, and sassafras were found to be less resistant to fire damage than oaks.

Little mortality occurs from low-intensity fires once hardwoods are greater than 3 inches in diameter at breast height (d.b.h.) (Chen, Hodgkins, and Watson 1975; Goebel, Brender, and Cooper 1967; Van Lear and Waldrop 1988). Most southern yellow pines are rarely killed once greater than 8 to 12 feet tall or more than 2 inches in groundline diameter (Cain 1985a; Komarek 1974; Wade 1986). Walker and Wiant (1966) state that shortleaf pine mortality from growing season headfires was negligible once they were greater than 4 inches d.b.h.

Protective adaptations such as protected buds, thick bark, ability to resprout, and natural pruning of lower branches decrease the risk of plant injury or death (Gill 1981; Van Lear 1985). When little damage is done to the buds of pines they can survive even severe needle loss (Wade and Johansen 1986a, 1986b).

Tree bark provides protection from fire temperatures. Species which have thicker bark are much less susceptible to fire damage (Hodgkins 1958; Langdon 1971; Wade 1986). In addition, natural pruning of lower branches of many pine species prevents low to moderate intensity prescribed fire from reaching tree crowns. Hare (1965) determined that tree species differ significantly in their resistance to damage by fire due to differences in bark insulation effectiveness and thickness.

Among hardwoods, beech, birch, and maple are thin barked species that are susceptible to basal stem injury and root damage by fire (McCarthy and Sims 1935).

Species resistance increases with tree diameter, due to increased bark thickness and crown height with age, and is also dependent on the intensity and duration of fire (McCarthy and Sims 1935).

Eastern redcedar, due to its inability to resprout, thin bark, flammable foliage, and roots near the ground surface, is intolerant of fire and can be killed by light surface fires (Arend 1950; Fowells 1965; Johnson and Schnell 1985b).

Ability to resprout when the above-ground portion of the plant is killed is another important adaptation. Although pines are normally more resistant than hardwoods to damage from fire, if pines are top-killed (when the entire above-ground portion of the plant is killed) they do not readily resprout. Exceptions to this are shortleaf pine which will readily sprout when topkilled by fire (Walker and Wiant 1966).

The effects of fire on various community types found at the Buffalo National River park was examined by Johnson and Schnell (1985b). The area is located in the Boston Mountain section of the Ozark Plateau physiographic province. Of the six sites examined, three were forest burns of light to moderate intensity. Plant mortality was dependent on size of plant stems, plant characteristics (bark thickness, sprouting capacity), and fire intensity. They observed that shortleaf pine, almost all of the hardwood species, and most of the shrubs and vines in the area of the Buffalo National River were fire-adapted species that had protective thick bark and/or were vigorous sprouters after being topkilled by fire. They also found that species not well adapted to fire, such as beech, maple, and linden, were either not commonly found in the area or their habitats were restricted to the more protected north and east facing slopes where fire is not a common occurrence.

Prescribed fire increases basal sprouting of hardwood species (Augspurger and others 1986; Danielovich and others 1987; Sanders, 1985; Van Lear and others 1983). This ability decreases with increasing age and size of the hardwoods. Some hardwood species that have proven to be vigorous sprouters when topkilled by fire include oaks, black cherry, red maple, dogwood, blackgum, sourwood, and basswood (Fennell and Hutnik 1970; Henderson 1986; Teuke and Van Lear 1982).

Fire type and behavior also determine whether plants are injured or killed. In the mountains, intensity and rate of spread of surface fires depends upon amount and type of fuel present, fuel moisture, slope, aspect, wind speed and direction, season, temperature, and humidity. Slope, aspect, wind speed, and direction are especially critical variables when trying to predict fire behavior. Fires spread significantly faster when moving upslope than they do across level terrain (Rothermel 1983).

Three types of fire occur. Crown fires consume the tops of trees, are very intense, and kill most vegetation. Surface fires consume woody shrubs, vines, and herbaceous vegetation. Ground fires burn below the surface and kill the roots of plants.

Surface fires are the fires manipulated for prescribed burning. Intense surface fire in areas with large amounts of available, continuous fuel create a high risk of injury or death to vegetation. According to Langdon (1981), backing fires with flame lengths of 3 feet or less develop fireline intensities to 60 Btu/ft/sec, while flanking and strip-head fires develop fireline intensities from 60 to 160 Btu/ft/sec (flame heights of 3 to 4.5 feet). Prescribed fires with flame lengths greater than 5 feet (190 Btu/ft/sec) may not be controllable. He also noted that at an intensity of 600 Btu/ft/sec (flame heights of 8.5 feet), surface fires are not generally controllable and may move into the crown fire category.

Effectiveness of upslope and downslope fires in controlling competing vegetation and reducing fuel levels was examined by York and Buckner (1983) for a Cumberland Plateau site. Their study found that upslope and downslope fires were equally effective for understory hardwood topkill (92 percent) and fuel reduction (51 percent); however, upslope fires had greater crop tree mortality, significantly higher rates of spread (212 ft/hr versus 66 ft/hr), and were more difficult to control.

Season

Temperature, length of exposure, and season significantly affect plant survival. According to Hare (1961) plant tissues are instantly killed at 140°F. Johnson (1974) examined northern red oak seedling mortality after an early growing season burn in Wisconsin and found that mortality rates were related to temperatures at seedling root collars. Mortality rates were 71 percent when temperatures reached 220°F, 64 percent with temperatures between 140 to 219°F, and 19 percent when root collar temperatures were less than 140°F. Also, plants can be killed at somewhat lower temperatures when the duration of exposure is increased. The temperature the plant is exposed to depends on distance from the flames and fire intensity (Hare 1961; Wade and Johansen 1986a).

Growing-season fires injure or kill more vegetation than dormant season fires. In one study on an upland site in northwestern Alabama by Hodgkins (1958), burns conducted during August (growing season) killed 97 percent of 1-inch d.b.h. shortleaf and loblolly pines, and 60 percent of 2- and 3-inch d.b.h. pines. Burns conducted during January (dormant season) killed 41 percent of 1-inch d.b.h. pines, and no 2- or 3-inch d.b.h. pines. Wade (personal communication) found that, during the transition period between growing and dormant seasons, burns that scorch 100 percent of needles pose significant risks of mortality of slash pine only.

Lewis, Murphy, and Ehrenreich (1967) studied the effects of prescribed fire on plant species composition and forage production in the Missouri Ozarks. Their treatments included dormant season (March), early growing season (mid-April), mid-growing season (June), and late growing season (August) burns on both north to northwest and south to southwest facing slopes. They found that grass production increased during the first year after a dormant season or an early growing season burn. The increase in grass production, however, lasted only 1 year. While late growing season burns resulted in the greatest production of forbs the first year after the burns, the increased production lasted for 3 years. All burning treatments increased legume production. Lewis, Murphy, and Ehrenreich also found that burns conducted in March increased the number of hardwood srouts; while later burns decreased the number of hardwood sprouts. Sites where burns were conducted later in the growing season on south slopes had less hardwood sprout survival than those on north slopes due to increased mortality from drier fuel conditions.

In a shortleaf pine-mixed hardwood stand in the Ouachita Mountain area of southeastern Oklahoma, Nickles, Tauer, and Stritzke (1981) studied the effects of prescribed fire on shortleaf pine when hardwoods were treated with hexazinone several months prior to burning. The area received the herbicide treatment in May and was prescribed burned the following September. The area was burned 2 days after receiving significant rainfall (2.75 inches), with an average flame height of 20 inches. Nicles, Tauer, and Stritzke found that fire intensity was greater on the herbicide treated plots due to the accumulation of additional fuels and drier fuel conditions. Crown scorch on the herbicide plots occurred on over 60 percent of the trees over 19 feet in height while on the untreated control plots, little scorch occurred on pines greater than 13 feet in height. However, shortleaf pine mortality was not significant when the pines were greater than 13 feet in height. The treatment resulted in a precommercial thinning of the pines, with the highest pine mortality occurring to seedlings and saplings less than approximately 1 inch in groundline diameter and also less than 7 feet in height.

York and Buckner (1983) in conducting prescribed fires during May, August, and October in a 26-year old loblolly pine stand found that the early growing season burn (May) created the most intense fire and caused the most pine crop tree mortality (22 percent). However, it was the most effective in competition control (98 percent hardwood topkill) and fuel reduction (66 percent). Burns conducted during August and October were less effective due to difficulties with higher humidities and fuel moisture levels.

Hodgkins (1958) found that August burns top-killed 62 percent of 1-inch d.b.h. hardwoods, 52 percent of 2-inch d.b.h. hardwoods, and 38 percent of 3-inch d.b.h. hardwoods; while in January 46 percent of 1-inch d.b.h. hardwoods, 5 percent of 2-inch d.b.h. hardwoods, and no 3-inch d.b.h. hardwoods were top-killed. Within 2-1/2 years dense new hardwood growth replaced the top-killed individuals on all burn plots. Danielovich and others (1987) determined that intense late growing season site preparation burns (August), of areas containing standing residual hardwoods, topkilled 64 percent of all residual stems. The smaller diameter stems were more readily topkilled; more than 70 percent of the stems 3 to 4 inches in stump diameter and more than 80 percent of the stems 1 to 2 inches in stump diameter were effectively topkilled.

Lotti, Klawitter, and Legrande (1960) determined that dormant season fires did not kill rootstocks of hardwoods; top-killing occurred but the hardwoods resprouted. They found that growing season fires not only top-killed stems but also killed the roots of many hardwoods. However, Langdon (1981) found that growing season burns for 10 consecutive years were required to kill all rootstocks. Annual winter burns did little to kill rootstocks even after 30 consecutive years of burning. Growing season burns were found by Ferguson (1961) to be the most effective in topkilling stems and that 90 percent of the stems resprouted. Early and late growing season burns completely killed 10 percent of oak stems, while dormant season burns completely killed less than 2 percent of the oaks in the study area. Brender and Cooper (1968) also determined that greater mortality to understory hardwoods occurs with growing season fires. Chen, Hodgkins, and Watson (1975) found no significant difference in understory hardwood mortality, however, between growing- and dormant-season burns. They determined that growing-season burns reduced vigor of resprouting hardwoods.

Some of these responses are due to seasonal temperature differences. Dormant season air temperatures are generally low and more fire heat is needed to reach the lethal 140°F mark than during the growing season when ambient air temperature is quite high (Fennell and Hutnik 1970; Wade 1983; Wade and Johansen 1986b).

Mortality cannot be easily determined immediately following a fire. Some external indicators of fire injury to plants include color changes in needles or leaves, bark scorch, and possibly pitch flow (Hare 1961). Loomis (1973) indicated that accurate damage estimates in hardwoods that include both delayed mortality and obvious wound development can be made after 1 or 2 growing seasons. Injuries may only set back or weaken plants. Accurate losses from severe fire may not become apparent for several years.

Prescribed fire can cause less immediate effects than obvious plant injury or mortality. These latent effects include changes in susceptibility to insects and disease, reproduction, nutrient content, and growth response.

Plant Susceptibility

Fire can increase or decrease plant susceptibility to damage from insects and disease. Wounds such as fire scars increase susceptibility by weakening plants and providing entry points for insects and disease. Additional mortality can occur from stem breakage at wounds (Fennell and Hutnik 1970).

Paulsell (1957), in the Missouri Ozarks, found that species such as white oak, scarlet oak, black oak, and southern red oak were more susceptible to basal scarring from fire than species such as post oak or various hickories.

Fennell and Hutnik's (1970) review of a study by Gustafson outlines decay losses from fire as being dependent upon species growth rates, bark thickness, resistance to decay, and area of cambium killed. Hardwood species that were most severely damaged by fire through decay losses were dogwoods, sourwoods, maple, and beech; followed by hickories, blackgum, elm, ash, basswood, and butternut. Least damaged were oaks, yellow poplar, and black walnut. In species that have low resistance to decay, stems may be significantly affected above the area of obvious wounding. Berry (1982) states that in some of the more susceptible species such as sugar maple, decay may be found 5 feet above a fire scar, while in ash, decay can spread 1.5 inches/year starting 2 or 3 years after being wounded. In more resistant species like white oak and black oak, loss of stem quality will be minimal where wounds are less than 6 inches wide, but oaks with fire wounds greater than two-thirds the circumference of the tree 1 foot above ground level should be removed. Nelson, Sims, and Abell (1933) correlated wound size with amounts of bark discoloration. They diagramed bark burn, char, and scorch areas on yellow poplars and oaks from a mountainous site in Virginia that received a very severe early growing season fire. One growing season later they removed the bark to diagram the wounds. They found yellow poplars more resistant to wounding than oaks; and that even when high amounts of bark were discolored, larger diameter poplars developed small wounds.

On a Southern Appalachian mountain mixed pine-hardwood site, Sanders, Van Lear, and Guynn (1987) found that low intensity dormant season backing fires, with average flame lengths of 6 inches or less, caused cambium damage to 20 percent of hardwood trees 3 to 5.5 inches in diameter, 5 percent of hardwoods 5.6 to 10.5 inches in diameter, and 4 percent of hardwoods 10.6 to 15.5 inches in diameter. Hardwoods greater than 15.5 inches in diameter had no cambium damage. They concluded that low intensity prescribed fires would have little to no adverse effect on stem quality of medium to large diameter (5.6 to greater than 15 inch) mature hardwoods.

Fire decreases disease susceptibility by reducing or controlling annosus root rot of loblolly and slash pine (Froelich, Hodges, and Sackett 1978), and fusiform rust of loblolly and slash pine (Hare 1961; Lotan and others 1981). The quality of oak sprouts may be improved through the use of prescribed fire by producing sprouts that originate lower on stumps; this may provide more decay resistant sprouts (Augspurger and others 1986; Roth and Sleeth 1939).

Reproductive Success

Success of reproductive functions such as germination, flowering, fruiting, and seed production is affected by fire. In southern Arkansas the use of prescribed fire for seedbed preparation and as an understory control tool in uneven-aged pine stands is currently being researched at the Crossett Experimental and Demonstration Forest (Farrar 1984).

Cushwa, Martin, and Miller (1968) observed that during simulated fire conditions moist heat significantly increased the germination of some species of legume seed. Fire may cause the seed in the soil to break dormancy, but can reduce germination and destroy seeds when lethal plant temperatures are reached.

Prescribed fire enhances the regeneration of yellow poplar by releasing seed stored on the forest floor (Shearin, Brunner, and Goebel 1972).

Seeds of other species are not as resistant to heat damage. Among oak species, red oak acorns are most resistant to heat damage, while white oak and black oak are least resistant (Fennell and Hutnik 1970). In general, germination success is directly enhanced by the reduction of competition for light and nutrients and by seedbed preparation that exposes some mineral soil. When naturally regenerating shortleaf pine, Williston and Balmer (1980) recommend seedbed preparation several months prior to seed-fall, with a treatment of competing hardwood species prior to the seedlings first growing season, and a release treatment in approximately 3 years. They found seedbed site preparation by prescribed burning increased the percent of pine stocking over that of unburned areas from approximately 54 to 83 percent. Van Lear and others (1983) also found that the timing of prescribed burns for seedbed preparation is critical. Competing vegetation will prevent seedlings from becoming established when areas are burned too far in advance of seedfall. They recommended a late summer or early fall burn for seedbed preparation when regenerating an area using seed in place. However, when overstory species are severely wounded and receive high amounts of crown damage following a fire, seed production may be restricted for several years (Fennell and Hutnik 1970).

Early growing season burns in an Eaton and White (1960) study increased the number of sprouts and buds of lowbush blueberries. Blueberry production is stimulated and maintained by early growing season burns that are implemented prior to spring growth (Kautz 1986). Kautz states that blueberry production is highest the second year following fire, by five years production drops to low levels. A two or three year burning cycle was recommended to maintain high production levels. Stransky and Halls (1979a) found that dormant season burns produced an increase in the fruit yield of dogwood but in general produced a mixed response of fruit yields of woody plants.

Nutrient Content

Nutrient content of some forage species is increased by prescribed burning. Campbell and others (1954) found both protein and phosphorus are increased until May by late dormant season burns.

Growth Response

Prescribed fires can change the environment in which plants grow. They remove litter from the ground surface, and temporarily reduce other woody or herbaceous species that compete for growing space, moisture, nutrients, and light required for optimal success in germination and establishment. Growth responses from burning have been positive and negative.

Over 4 summers in southern Arkansas Zahner, (1958) measured the proportion of available soil water utilized by understory hardwoods, and whether prescribed burning to control understory hardwoods affects available soil moisture. He found that understory hardwoods increase the rate of soil moisture depletion. These loss rates were 25 percent faster on plots with untreated understory headwoods as compared with plots where the understories were completely eliminated with herbicides. Zahner also found 50 percent greater moisture levels during the month of July on areas with no hardwood understory compared with plots that left the understory untreated. Plots that were burned had more available moisture than the untreated plots but significantly less moisture than the herbicide treated plots.

Depending upon fuel load and weather variables, low to moderate intensity fire can be expected to result in low to moderate amounts of crown scorch. Minor amounts of crown scorch, approximately 0-15 percent, were found by Johansen (1975) to enhance the growth of young slash pine. He also concluded that needle scorch of less than 40 percent of crowns did not reduce growth. Lilieholm and Hu (1987) working with loblolly pine also found that light amounts of scorch may increase growth. Waldrop and Van Lear (1984) found that moderate crown scorch did not affect the growth of unthinned young loblolly pine trees of dominant or codominant crown classes. Complete crown scorch caused 20 percent mortality of codominant and 30 percent mortality of intermediate crown classes. High amounts of scorch can be expected to produce decreases in diameter and height growth of loblolly pine and slash pine (Cain 1985b). In a study by Johansen and Wade (1987) slash pine with extreme amounts of crown scorch suffered no mortality during the first postfire growing season but severely scorched trees averaged 60 percent growth loss two seasons later. Slightly scorched trees averaged a 15 percent growth loss.

After a winter backing fire in a 4 year old loblolly pine stand, Waldrop and Lloyd (1988) found no loss of diameter growth, but a significant reduction in height growth occurred. During the first year after burning, height growth was reduced for each of the first three growth flushes, even when crown scorch was light. An additional loss of growth occurred during the first flush when crown scorch was heavy.

Jemison (1944) studied effects of basal wounding on the growth rate of some Southern Appalachian hardwood species and found that even severe basal wounding by fire had no significant effect on the diameter growth rate of 8 to 10 inch white oaks and black oaks, and 8 to 18 inch yellow poplars 7 to 14 years after a fire. Jemison also found that wounds caused only temporary obstruction to the flow of food and water in these trees, movement around the wounds quickly developed.

Johnson and Schnell (1985a) examined the effects of light, moderate, and severe fire intensity on various forest community types at Hot Springs National Park located in the Ouachita Mountain section of the Ouachita physiographic province. An oak-hickory-pine site with a south facing slope that had a severe intensity burn caused an increase in seedling origin pines and a significant decrease in cherries (Prunus serotina). Understory species such as winged sumac (Rhus copallina), blackberries (Rubus spp.), blueberries (Vaccinium spp.), and Japanese honeysuckle (Lonicera japonica) significantly increased; while poison ivy (Rhus radicans) decreased. A moderate intensity fire on a north-facing slope in an oak-hickory-pine community caused no significant impacts to overstory or understory species of trees, shrubs, or vines; although some species less than 4 inches d.b.h. were completely killed. Almost all woody species that were top-killed resprouted and regrowth was approximately 8 to 16 inches 9 weeks after the fire. Johnson and Schnell found that a light intensity prescribed fire on a north-facing slope also caused no significant changes to overstory or understory species of trees, shrubs, or vines. Within 6 weeks of the burn nearly all woody stems had resprouted and were approximately 4 to 6 inches tall, with some cherries approximately 18 inches tall.

Community structure can be altered by temporary changes in canopy position and species composition. More long-term effects from prescribed fire occur as successional changes resulting from the interaction of species composition with fire intensity, frequency, and season over time.

Canopy Position

Lay (1967) noted that fire effects on understory vegetation are dependent on characteristics of understory prior to treatment. When fire is used in an understory of low-growing woody species, the amount of browse is reduced temporarily, but the quality of browse is improved. When fire is used in higher understory, canopy position is lowered as tops are killed, but resprouting is rapid, and ultimately more browse becomes available. Chen, Hodgkins, and Watson (1975) determined that winter and summer burns reduced canopy height of woody species by more than 6 feet, and summer burns additionally reduced vigor of resprouting hardwoods. A prescribed burn study in an oak-pine site showed a decrease in the height of the understory hardwoods but an increase in the total number of hardwood stems which hindered shortleaf pine regeneration (Fennell and Hutnik 1970).

Species Composition

Species composition changes occur with increased fire intensity and frequency. Season of burn is also an important variable. More intense fire causes greater shifts in species composition by reducing small woody species and increasing quantities and types of herbaceous vegetation through the preparation of seedbeds more favorable to herbaceous species (Van Lear and Johnson 1983). Sanders (1985) found that herbaceous species under hardwood and pine types increased after one low intensity burn but the increase was not significant. As intensity increases, legumes and other forbs and grasses are especially favored (Cushwa, Brender, and Cooper 1966; Cushwa and Redd 1966; Czuhai and Cushwa 1968).

Johnson and Schnell (1985b) concluded that most light to moderate intensity fires in Buffalo National River area will not change plant species composition. Effects on understory woody plants is temporary as native plant species are fire-adapted, sprout growth quickly reoccupies a site, and fire may be necessary in order to retain both oak-hickory and oak-hickory-pine communities.

Single burns that occur once per stand rotation, especially of low to moderate intensity, do not significantly change species composition. One winter (dormant season) or summer (growing season) burn initially reduces hardwood vegetation, but it recovers to previous levels in 5 to 7 years (Langdon 1971). Wade and Wilhite (1981) noted woody species recovery to nearly preburn levels by 6 years. Huntley and McGee (1983), Lorimer (1985), and Martin and others (1979) also concluded that burning initially reduces woody species coverage, but woody species composition is not significantly changed.

One winter burn was found by Moore, Swindel and Terry (1982a) to reduce woody species coverage, increase herbaceous species frequency and biomass, and encourage a greater variety of understory species. Prior to burning they encountered 30 woody and 37 herbaceous species, but after burning they encountered 32 woody and 61 herbaceous species.

Phillips and Abercrombie (1987a, 1987b) used early growing season site preparation burns on medium quality southern Appalachian Mountain sites to establish mixed pine-hardwood stands. After the regeneration cut, standing residual stems are felled after the initial growth period in the spring. During July these areas are broadcast burned with an intense fire over a moist fuel bed. Results indicate good growth and survival of planted pines along with good growth and form of hardwoods. Burning temporarily knocks back hardwood sprouts allowing pine seedlings to become established.

In West Virginia, Carvell and Maxey (1969) examined changes in species composition three growing seasons following wildfire in dense cove hardwood sapling stands. Approximately 44 percent of the cove hardwood species (primarily yellow-poplar, basswood, northern red oak, cucumber tree, and white oak) were dominant trees prior to the fire; while 23 percent were dominant after the fire. Oak and hickories increased (54 percent dominant) due to their resistance to fire damage.

Lorimer (1985) speculated that unsuccessful oak regeneration on better sites may be due to the lack of periodic fire during the past few decades, where historically these oak dominated areas had frequent fires which selected against oak competitors and favored the fire-resistant oaks.

Due to understory competition from other species, oak regeneration is more difficult on moist, fertile, cove sites than on drier sites. Some research indicates that environmental conditions on cove sites have been sufficiently altered by the exclusion of fire so as to prohibit oak regeneration (especially that of northern red oak). Further research is needed to determine whether prescribed fire has a role in promoting advance oak regeneration on these better quality cove sites. Research needs to find out whether or not there is a combination of season, frequency, and number of burns that would stimulate oak reproduction.

Teuke and Van Lear (1982) studied the effects of dormant season backing fires on understory species composition and effects on oak regeneration in mixed pine-hardwood stands in the mountains of north Georgia and northwestern South Carolina. These burns only slightly improved the competitive position of oak regeneration through improved form, density, and decrease of oak competitors. The size reduction of oak regeneration proved to be a significant disadvantage. On better quality cove sites, Loftis (1988) found that one low intensity prescribed burn had no positive effects on oak regeneration. McGee (1979, 1980a) found no significant effects of one prescribed fire on species composition and dominance in 5 to 6 year old hardwood stands in northwest Alabama. Young stands were topkilled but quickly resprouted, with most species retaining their same relative competitive positions as before the prescribed fire. McGee concluded that one prescribed fire doesn't favor the development of oak regeneration but that possibly additional burns or burns in stands less than 5 or 6 years old would benefit the competitive position of oaks.

Nyland, Abrahamson, and Adams (1983) recommend two successive early growing season site preparation burns implemented two to three years apart to promote oak regeneration and to sufficiently suppress competition. In West Virginia, Wendel and Smith (1986) also found that one burn doesn't enhance oak reproduction and suggested multiple low intensity burns may be necessary to improve the competitive position of oak regeneration under an overstory. Paulsell (1957) in observing the effects of repeated fires on young hardwood stands in the Missouri Ozarks found that blackjack oak, hickory, and post oak were favored by these fires and increased their proportion in the original stand. Van Lear and Johnson (1983) suggest initiating frequent low intensity burns for oak regeneration 10 to 15 years prior to harvest.

Harlow and Bielling (1961) recommend burning cycles for specific objectives; a 3-year cycle to produce high amounts of forbs and legumes, 4 to 6 years for best understory hardwood growth and mast production, and annual burns for the greatest variety and number of plant species. Johnson and Landers (1978) recommended a 3-year burning cycle for the production of fruiting plant species for wildlife.

Fire Frequency

Frequency and season of burn combine to create significant impact on species composition. Frequent prescribed burns reduce woody species and increase herbaceous species (Lewis and Harshbarger 1976). Paulsell (1957) found that annual burns significantly increased both the number of different species as well as the number of individuals of most species of forbs and grasses. He concluded that this was due to the increase in openings from tree mortality and also due to a reduced litter layer from the early spring burns. He also observed a significant increase in mosses on both annually burned and periodically burned plots, which may decrease oak seedling establishment by facilitating predation by wildlife and through increased exposure to freezing temperatures.

Frequent burns result in less vigorous sprouts and fewer sprouts as more rootstocks are killed with each successive fire (Johnson 1982; Chen, Hodgkins, and Watson 1975; Grano 1970a; Trousdell 1979). Paulsell (1957) also found that the greatest tree mortality from repeated prescribed fires in upland hardwood stands (88 percent) were in the smaller diameter classes (1.6-4.5 inches). Among oak species, post oak had the least mortality while scarlet oak and southern red oak, followed by black oak, had the greatest mortality.

Keetch (1944) found that hardwoods' ability to resprout was not reduced by three successive moderate to high intensity early growing season burns and no losses in growth rate or vigor occurred. While Yocum (1972), in conducting prescribed burns in a 60-year old shortleaf pine stand in the Ouachita Mountains, found that three burns significantly reduced the number of hardwood stems in the 0.6 to 5.5 inch size class by 33 percent. However, Van Lear and others (1983) found that three consecutive burns in loblolly pine stands (March 1977, September 1978, and September 1979) significantly reduced the total number and size of competing hardwood understory species.

Thor and Nichols (1974) examined the effects of annual and periodic (every 5 years) winter burns on hardwood understory species and reproduction. They found that compared with the no treatment area (8070 stems/ac), annual (13,051 stems/ac) and periodic (12,540 stems/ac) prescribed burn areas had significantly more hardwood understory stems. Southern red oak had the greatest increase in stems per acre on both burns, followed by post oak and scarlet oak. On the no treatment area, blackgum had the greatest number of stems per acre.

Lotti, Klawitter, and Legrande (1960) determined that woody species control was minimal with annual winter burns because rootstocks of most species survived, and once annual burns were discontinued woody species regained dominance. Van Lear and Johnson (1983) also noted that annual winter burns do not reduce the number of hardwood sprouts but only affect the size of sprouts, whereas annual summer burns effectively eliminate small woody stems. Frequent prescribed burns can effectively prevent seedling establishment of woody species. Dormant season burns are not effective in killing the roots of woody species, but frequent growing season burns are, and also result in greater changes in species composition.

Successional Patterns

Succession refers to changes in vegetation over time. Specific patterns of change vary with site, and depend on the type of disturbance that initiates changes. Succession following prescribed fire differs from patterns generated by applying mechanical tools.

Following fire, forb dominance is followed by perennial grass dominance and ultimately by woody species dominance (Hare 1961). This change in growth forms is a commonly reported pattern, but the herbaceous community that dominates after fire is very different than the herbaceous community that is generated after major soil disturbances. Fire maintains the herbaceous layer of fire-dependent (e.g., pine/wiregrass) communities; absence of fire allows shrub invasion and consequent species loss. Understory burns in southern pine forests retard the replacement of pines by invading hardwoods (Pyne 1984). Prescribed fire in grasslands favors grasses and retards woody species encroachment.

In the Arkansas Ozarks, due to decreased moisture availability, Arend and Julander (1948) found less shrubs and vines and more grass species on poor oak sites (site index less than 45) than on good oak sites (site index greater than 60). They found that among the white oak, white oak-black oak-red oak, black oak-hickory, and post oak-blackjack oak forest types that only 2.5 to 3 percent of the forest floor was covered by herbaceous plants or shrubs and vines. They determined that the amount of ground cover increased as stand basal area decreased.

Fire intensity, frequency, and season are some of the most important factors determining what species dominate. Fennell and Hutnik (1970), reviewing work by Ahlgren, cite 13 factors that can affect vegetation succession following fires: pre-burn condition, season, seed supply, fire intensity, ash concentration, subsequent mineral nutrition, soil moisture, rainfall, humidity, soil temperature, air temperature, animal populations, and plant competition. Frequent fires, especially during the growing season, restrict development of woody species and promote herbaceous species.

Lewis and Harshbarger (1976) reported the effects of 20 years of prescribed burning in South Carolina flatwoods. Their study looked at seasonal and frequency impacts on woody and herbaceous vegetation from annual, biennial, and periodic dormant and growing season burns. They concluded that after 20 years of burning the understory had been significantly altered. Annual summer (growing season) burns eliminated almost all shrubs, had the highest number of herbaceous species (29), and grasses became the dominant herbaceous species. Annual winter (dormant season) burns resulted in numerous low-growing shrubs, had the next highest number of herbaceous species (26). Biennial summer (growing season) burns were similar to annual summer burns in that most shrubs were reduced, it had the third highest number of herbaceous species (24). Both types of periodic burns occurred when 25 percent of hardwood stems reached 2 inches in diameter. Periodic summer (growing season) burns created site conditions dominated by low-growing shrubs, had an intermediate number of herbaceous species (22). Periodic winter (dormant season) burns also left sites dominated by low-growing shrubs, had the second lowest number of herbaceous species (18). The control area was not burned, and was dominated by low-growing shrubs. It also had the lowest number of different herbaceous species (11).

Results of this study after 30 years, summarized by Waldrop and others (1987), determined that season and frequency combine to produce significant differences in understory species composition and size class development. On periodic dormant and growing season burns, two size classes developed consisting of hardwood understory species greater than 6 inches d.b.h., and those less than 2 inches d.b.h. The larger size class represented species not topkilled at the initiation of the study. The smaller size class represented sprouts of species that were topkilled by each fire. No intermediate classes developed because burns were frequent enough to prevent growth into size classes between 2 and 6 inches. Annual winter (dormant-season) and biennial summer (growing season) burns were similar in that both had many understory woody species less than 3 feet tall which are topkilled sprouts. They differ in that more grasses occur on biennial summer burns. Annual summer burns still produced the greatest reduction in woody understory vegetation. Frequent burning killed woody root systems and promoted development of an herbaceous understory. Annual growing season burns kill root systems by gradually depleting root carbohydrate reserves. Oak root systems were the most resistant thereby giving them an advantage over other species when burning is frequent.

2. Effects of Mechanical Methods

a. Forest

Little to no research has been done on effects of mechanical tools on mountain sites. Use of these tools is expected to produce similar results to their use on Piedmont and Coastal Plain sites.

Injury and Mortality

Mechanical methods can injure or kill vegetation. Mechanical tools, in increasing order of intensity, are: mowing, chopping, shearing, scarifying, ripping, piling, raking, and disking. The use of mechanical methods can be severely restricted due to seasonal impacts. In the Ozark/Ouachita area, the use of heavy mechanical equipment predominately occurs during the driest months of the year (June through September).

Shearing and mowing tools cut only the above ground portions of plants. They effectively kill species, such as most pines, that do not have the capacity to resprout. Piling tools are normally used after stems have been sheared or manually cut. Mortality is low as long as plants are not uprooted.

Chopping tools cut above ground stems, but they also can sever plant roots or rhizomes (horizontal stems below ground). Blade cutting depths can range from 1 to 10 inches depending on the size and weight of the choppers. When root systems are not severely damaged, sprouting species quickly recover.

Significantly higher injury and mortality occur with more intensive raking, disking, ripping, and scarifying tools because more rootstocks are affected. In central Alabama, Miller (1980) determined that shearing and raking material into windrows is more effective than chopping to control sprouting. He reported 25 percent fewer sprouts on windrowed compared to chopped sites two growing seasons following treatment.

Liming (1945) examined the effects of various levels of ground disturbance on the success of natural shortleaf pine regeneration in the Missouri Ozarks. Treatment intensity included all litter being removed and soil tilled to a depth of 2 inches, soil tilled with litter in place, litter removed, litter burned, and no disturbance of soil and litter. Only the litter removed with soil tilled treatment increased the amount of seedlings established. However, he also examined the effect of overstory density levels on the subsequent survival of the seedlings and found that after 5 years the sites where the overstory was reduced by 75 percent had 2.5 times the number of surviving seedlings with 7 times the height growth than that of sites with dense overstories. Liming concluded that the amount of overstory present on areas to be naturally regenerated to shortleaf pine severely limited seedling survival regardless of the site preparation treatment.

Mechanical methods effectively reduce or control woody and herbaceous competition, permitting increased survival and growth of planted pines and hardwoods. These effects may be increasingly significant where seasonal water availabilty limits growth. According to Walker and Wiant (1966) shortleaf pine occurrence may be more prevalent in the Missouri and Arkansas Ozarks on south and west facing slopes due to soil moisture conditions as shortleaf pine is a more effective competitor on these sites because it is more drought resistant than species such as black oak, southern red oak, and scarlet oak. They also stated that shortleaf pine is as drought resistant as white oak but it is less drought resistant than eastern redcedar. Lowery (1986) states that on many shortleaf pine sites, growing season water availability is a major growth-limiting factor.

Plant Susceptibilty

Williston and Balmer (1980) state that shortleaf pine sites prepared by mechanical equipment have 1.5 to 4 times the average number of growing tips infested by the Nantucket pine tipmoth than areas site prepared using herbicides. They also state that on herbicide treated sites, parasites of the Nantucket pine tipmoth are more active.

Competition

On a lower piedmont site, Edwards (1986) observed that more intensive treatments were more effective in reducing competition, producing greater seedling survival after the first growing season and the best height growth responses at the end of two growing seasons. Slay and others (1987) in north Louisiana did not find significant differences in survival; all treatments produced acceptable survival. They did, however, note the relationship between amount of competing vegetation reduction and seedling growth response.

Treatments that are combinations of tools are generally more effective in competition control. Stransky and Halls (1981) compared burning, chopping and burning, and a treatment consisting of shearing, raking, burning, and disking on east Texas loblolly pine-shortleaf pine-hardwood sites. The latter, which is the most intensive, provided the greatest amount of competition control and produced significantly greater tree growth than the other two treatments. Chopping and burning produced the next highest response, followed by the burning only treatment.

In southern Arkansas, Haywood, Thill, and Burton (1981) compared growth responses of loblolly pine seedlings on sites that received the following seven treatments: burn-underplant-inject residuals, chop-burn, chop-burn-disk, chop-wait several weeks-chop again, shear-burn, shear-windrow, and shear-windrow-disk. Their results showed that all treatments produced adequately stocked stands but the least number of free-to-grow seedlings and volume per acre occurred on the underplant-injected plots.

Growth Response

Increases in seedling survival and growth have been reported for scarifying tools through the creation of improved microsites, providing nutrient pools near the seedlings, and the control of competing herbaceous vegetation (Alm, Long, and Eggen 1988).

In reviewing work by Bower and Smith, Walker and Wiant (1966) related that direct-seeded shortleaf pine survival and subsequent stocking in the Ouachita Mountains was increased by treatments that exposed mineral soil.

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In one study on a Ouachita Mountain site, ripping caused no effect on first or second year survival of loblolly pine, but provided increased soil moisture in the upper 4 inches of soil. By the end of two growing seasons, ripping increased total seedling height by 10 percent (Wittwer, Dougherty, and Cosby 1986).

Stafford, Torbert, and Burger (1985) showed significant loblolly survival, height, and diameter growth responses with shearing, raking, or disking treatments on piedmont plateau sites. In their study all disking treatments increased early growth from what they attributed to relieving compacted soil conditions. Studies by Mann and Derr (1970) and Tiarks (1983) have shown similar positive growth responses for loblolly pine.

Scholz (1955) found that seedbed preparation by disking under a mixed oak overstory more than tripled northern red oak regeneration. The treatment was applied prior to seedfall during a good acorn crop year. Disking has also improved survival and growth of planted hardwoods. On bottomland hardwood sites in western Mississippi, Kennedy (1981a, 1981b) compared mowing and disking treatments with a no treatment control plot for sycamore, green ash, nuttall oak, sweet pecan, cottonwood, and sweetgum. He found that disking provided hardwoods with additional water and nutrients by controlling vines and weeds. Seifert, Pope, and Fischer (1985) compared the effects of disking, disking and bedding, and a no treatment control on planted swamp chestnut oak. Survival did not differ between the two methods, but survival with no treatment was 15 percent lower than either method. Disking has also doubled the amount of survival, and increased height growth of cherrybark oak by 18 percent (Woodrum 1983).

Growth losses can occur from piling and raking treatments when nutrient displacement occurs. Swindel, Conde, and Smith (1986) found that tree height, basal area, and volume were smaller for trees not growing near or adjacent to windrows. They attributed this to the accumulation of soil and litter in the windrows. While Haywood, Thill, and Burton (1981) found no significant reduction in loblolly pine growth or yield in the area between windrows.

Lennartz and McMinn (1973) reported on the effect of low (burn only) to high (complete clearing) intensity site preparation treatments on pine height growth. Responses to mechanical treatments, though declining over time, were still significant 10 years after the initial treatment. However, several studies have shown that by 13 to 15 years the advantages provided by low to high intensity mechanical treatments are no longer significant for pine diameter, height, or volume growth (Buford and McKee 1987; Haywood 1980, 1983; Outcalt 1984; Tiarks 1983).

Species Composition

Shifts in species composition are caused by use of mechanical methods. Mechanical treatments reduce woody species and increase herbaceous species temporarily. In general, the more intensive a treatment the greater the shift in species composition.

Lewis, Tanner, and Terry (1987) noted that mechanical methods reduced woody species coverage but that overall species composition was not affected. Miller (1980) also determined that while tree, shrub, and vine species were 55 percent smaller on windrowed areas compared to chopped areas, there were no differences in overall species composition. Both areas had approximately 118 herbaceous and 15 grass species.

Comparing burning and disking treatments Buckner and Landers (1979) determined that herbaceous annuals and perennials are favored by disking. After one growing season single disked areas had better herbaceous growth and production than double disked areas, but during the second year the double disked areas yielded more herbaceous food plants and seed than even annually burned plots.

Successional Patterns

Following mechanical treatments sites are dominated by herbs, which eventually are replaced by invading shrubs and trees. Herbs that dominate after soil disturbing activities are most likely to be ruderal species with characteristics that allow them to colonize open sites. These characteristics include abundant seed production, rapid growth rates, short life cycles and easily dispersed seeds. Conversely, species typical of sites without soil disturbance tend to grow more slowly, produce seed less predictably, and not disperse their seed widely. The time required for woody plant recovery ranges from 5 to 10 years, and varies directly with the intensity of mechanical treatment.

Research has shown that following harvest and site preparation by low to high intensity mechanical methods, herbaceous species temporarily increase while woody species temporarily decrease. One study by Conde, Swindel and Smith (1983a) showed that by the second year after harvest and site preparation by chopping and bedding, herbaceous species dominated the site but woody species were beginning to recover. Their conclusions were based on measurements of woody and herbaceous species cover, frequency, and biomass. A more intensive mechanical treatment consisting of prescribed burning, shearing, piling, disking, and bedding, produced similar results but succession was set back further (Conde, Swindel and Smith 1983b). Woody species recovery was slower but after 2 years it was beginning to increase. After 5 years the lower intensity treatment area (chopping, bedding) was again dominated by woody species while succession on the higher intensity treatment area (burning, shearing, piling, disking, bedding) was proceeding towards a woody species community but was still dominated by herbaceous species.

Impacts from burning, chopping, shearing, and raking were analyzed by Stransky, Huntley, and Risner (1986). They found that 1 year after mechanical site preparation herbaceous species increased and woody species declined, with less decline on chopped than sheared and raked areas. After 3 years, herbaceous species peaked and woody species were almost back to pretreatment levels. During the 5- to 10-year period after treatment, herbaceous species declined as they were shaded out by the pine and hardwood canopy closure. Ten years after treatments, woody species had fully recovered.

Mechanical treatments are more effective than other methods, such as fire, in reducing woody species (Moore, Swindel, and Terry 1982b; Stransky, Huntley, and Risner 1986) and mechanically treated areas are slower to recover to pretreatment levels than other methods (Lewis, Tanner, and Terry 1987).

3. Effects of Herbicides

Herbicides are designed to injure or kill plants. The effect of a specific herbicidal treatment, however, is the result of many interacting factors including: initial vegetation onsite; selectivity of the herbicide and application method used; pattern in which the herbicide is applied; biochemical effects of the herbicide on vegetation; and timing of the treatment (Gjerstad and Nelson 1986; Norris 1981; Smith 1966). General discussion of vegetation effects is found below; further discussion of tools and herbicides is found in chapter II. Unless otherwise noted the following information about uptake, movement, and effectiveness of herbicides is from the 5th Herbicide Handbook of the Weed Science Society (1983).

Herbicides can be broadcast or more selectively applied. Broadcast application achieves uniform distribution of herbicide. Aerial and ground-mechanical applications of granular or liquid products are generally broadcast. Broadcast application is commonly used for site preparation, release, and rights-of-way maintenance (Cantrell 1985). Selective methods allow for incomplete area coverage or application to specific targets. Hand applications are generally target or spot specific (Williamson and Miller 1987). Directed foliar sprays, cut-surface treatments, and basal stem treatments are target selective; spot around and basal soil spot treatments are less so; grid soil-spot, banded foliar, and many herbaceous weed treatments are the least target specific of the selective methods. More selective application patterns have less risk of affecting non-target vegetation than broadcast applications. They are commonly used for site preparation, release, precommercial thinning, ROW maintenance, wildlife habitat improvement, and weed control in recreation areas.

Injury and Mortality

Rates of uptake and time until the first effects show vary with species, product, and environment (Gjerstad and Nelson 1986; Norris 1981). Fosamine is taken in through leaf, stem and root tissue (Kitchen, Rieck, and Witt 1980; Weigel, Beyer, and Riggleman 1978). Imazapyr and picloram enters either through the roots or leaves. Hexazinone is taken in primarily through the roots with some entering through leaves (McNeil, Stritzke, and Basler 1984). Sulfometuron methyl primarily enters through leaves, but there is some root uptake. Glyphosate and triclopyr enter primarily through leaves.

Some plant surfaces are designed to selectively protect the plant (bark on stems, wax on leaves) (Norris 1974). Penetration of these surfaces is enhanced by using additives such as diesel oil, kerosene, limonene, or mineral oil. Thickness of bark on stems or wax on leaves influence the effectiveness of a herbicide treatment even when an additive is used.

Once a herbicide is taken into a plant, it may move through plant tissues. Many herbicides concentrate in growing tissues and disrupt normal functioning. Some disrupt photosynthesis (glyphosate and hexazinone), some interfere with amino acid synthesis (imazapyr) (Peoples 1984), and others (fosamine, picloram, sulfometuron methyl (duPont 1982), and triclopyr) interfere with growth processes such as cell enlargement, cell reproduction, or bud formation and enlargement.

Translocation of herbicides in the plant generally follows the normal food movement system. Glyphosate, picloram, and triclopyr are translocated up and down in plants, accumulate in plant roots or root collars, and effectively suppress sprouting from stumps (Lewis, Zedaker, and Smith 1984; Troth, Lowery, and Fallis 1986; Warren 1980). Fosamine inhibits bud formation and growth, and is practically immobile; thus it can be used to chemically prune only a part of a plant (Coupland and Peabody 1981).

Some herbicides are broken down by plants. Limited information is available about the chemical breakdown products and their effects (Chrzanowski 1983; McNeil, Stritzke and Basler 1984; Sung, South, and Gjerstad 1985). Primary concern thusfar has been to determine and report what these degradation products are and how rapidly they are further decomposed. Herbidical, toxicological, or biochemical properties are, as yet, virtually unreported.

Plant Susceptibility

Effectiveness of herbicides varies among plant species. Fosamine, picloram, and triclopyr are used to control woody species and broadleaf weeds. Glyphosate, hexazinone, and imazapyr are effective against grasses, woody species, and broadleaf weeds. Sulfometuron methyl is used primarily to control weeds and grasses.

Some herbicides are essentially ineffective against certain plants. Though effective against most hardwood species, hexazinone has virtually no effect against yellow-poplar. Imazapyr gives limited control of locust, redbud, blackberry, and most legumes.

Some plants or groups of plants are extremely difficult to control, eg. glyphosate is fairly effective against sedges; picloram is used for kudzu control (Miller 1986).

Effects of herbicides also depend on season of application (Gjerstad and Nelson 1986; Norris 1981). Fosamine, which blocks spring bud break, is a very slow acting herbicide which is generally fall-applied; effects are usually not seen until the next spring. Spring or early summer foliar application of hexazinone is effective in controlling many woody species while application of picloram, sulfometuron methyl, or triclopyr is done in the spring, summer or fall (excluding droughty periods). Cut surface treatments are made throughout the year.

Several herbicides are soil active; once in the soil they can be taken up by plants. Hexazinone is currently produced in formulations labeled for soil application. Imazapyr, picloram, sulfometuron methyl, and triclopyr also have some soil activity. Non-target plants may be affected if they are within the treated area or if their roots grow into it. Hexazinone normally remains active in the soil for 2 weeks to 6 months; imazapyr remains active longer (appendix A).

Mineral oil has been shown to increase the susceptibilty of target grass to herbicidal activity without decreasing the target selectivity of the herbicide (King and Handley 1977). It has also been shown to improve the effectiveness of glyphosate in eliminating established rhododendron cover from a site (Tabbush and Sale 1984).

Reproductive Success

Herbicides evaluated do not appear to affect seed biochemistry or germination rates (Prasad 1984). Soil active herbicides do, however, affect young seedlings emerging from seeds in treated areas.

Use of mineral oil may affect flowering and seed set by non-target plants. While forest related data is unavailable, there is some international literature which relates to fruit/nut trees. Liotta and Maniglia (1979) report that mineral oil contacting growing tips negatively affect 1-1.5 cm tangerine initials, although both flowers and large fruit (3-3.5 cm) was unaffected. Moss (1976) reported a reduction of flowering by sweet orange when mineral oil was applied during the period of flower induction. And Procopiou (1973) reported that a dormant spray of mineral oil induced earlier flowering of cultivated pistacio. These results indicate the potential for affecting seedfall through the use of mineral oil in foliar sprays.

Growth Response

Seedling survival is reported to improve after herbicidal site preparation in many studies. Ferguson (1958) reports the best survival of loblolly pine seedlings when all hardwoods over 1 inch d.b.h. were controlled. Natural seedling establishment is reported to be most satisfactory after broadcast herbicidal site preparation (Loyd, Thayer, and Lowry 1978). Similar results are reported for yellow poplar, white pine and loblolly pine (McGee 1980b), for sweetgum (Morrissey and Ezell 1975), and for black cherry (Horsley 1981).

"No effect" on survival from herbicidal site preparation has, however, also been reported. Various southern yellow pines have been unaffected (Harrington 1960; Hatchell 1964; Plass and Green 1963; Williston and Huckenpahler 1958) as have white oak (Plass and Green 1963), eastern white pine (Plass and Green 1963; Sterett and Adams 1977), black walnut (Todhunter and Bieneke 1979), and eastern redcedar (Williston and Huckenpahler 1958). Morrissey and Ezell (1975) report a decline in oak regeneration as site preparation increases.

Mineral oil has been reported to temporarily reduce (1-7 days) net photosynthesis when applied to pecan leaves (Wood and Payne 1986). This is considered to have a minor potential for impact on non-target vegetation since the greatest use potential for mineral oil is in streamline herbicide application (not in foliar sprays).

Herbicidal site-preparation, broadcast or more selectively done, is reported as having beneficial effects on both height and diameter growth of hardwoods and conifers (Byrd and Foster 1982; Gjerstad, Nelson, and Minogue 1984; Holt and Nation 1974; Lowery 1986). Selective herbicidal site preparation can be done pre-harvest (within 3 years) to open the understory and permit seedling establishment (Loftis 1985). Pre-planting selective stump treatment allows control of stump sprouting by undesirable species. Done in conjunction with specific silvicultural systems, these processes will influence species composition in the subsequent stand (Horsley 1982).

Most papers indicate only limited between-treatment differences where herbicides were used. However, several report differences between herbicide methods and other treatment methods. In naturally regenerating stands Cain (1983) reports that a mow-and-disk treatment resulted in greater loblolly and shortleaf pine seedling density than mow-and-herbicide treatments. Maple (1965) reports that a rotary brushcutter treatment resulted in better stocking than either fire or herbicide treatments (though the latter were still significantly better stocked than control plots). In planted stands, Carter and others (1975) report no significant difference between burning and tree injection and shearing, piling, disking, and bedding; injected plots had slightly lower stocking, offset by slightly better height growth. They also report that aerial spray did not result in stocking or growth comparable to the tested mechanical treatments (sheared, piled, and bedded; sheared, piled, and disked; and, sheared and burned), but aerial treatment was less expensive and provided better wildlife habitat. Haines (1981) reports burning and chopping to be more effective than burning, chopping, or herbicide alone, or herbicide and burn treatments for site preparation.

Wittwer, Dougherty, and Cosby (1986) report that a preplant combination of ripping followed by band application of hexazinone to soil increased height and diameter growth of loblolly pine seedlings planted in southeastern Oklahoma. The combined treatment had greater beneficial effect on both height and diameter than indicated by the effects of each treatment alone. Improved water conditions and the reduction of competition, still evident at the end of the second growing season, are credited with the improved growth.

Release treatments which involve herbicides, either broadcast or more selectively applied, are reported to be highly effective in improving growth of desired pine or hardwoods (Grano 1970b; Knowe and others 1985; McConkey 1958; Michael 1980, 1985; Wendel and Lamson 1987; Yeiser 1986; Zutter and others 1987). Herbaceous weed control, by increasing water and nutrients available to pine seedlings, is reported to generate significant increases in survival and growth of planted pine seedlings (Glover, Knowe, and Gjerstad 1981; Nelson, Zutter, and Gjerstad 1985; Whipple 1962). Herbicidal release can be the difference between successful or unsuccessful pine planting (Wilson n.d.).

Several authors state that degree of release is critical to treatment success. Clason (1978) suggests that removal of either hardwoods or herbaceous competition alone is less effective than controlling both. Elwell (1966) found that a single herbicidal treatment to release shortleaf pine from hardwood competition was as effective as repeated treatments.

Papers by Russell (1971) and Walker (1954) stress the importance of treating during the first growing season. While stressing the importance of first season treatment Russell (1969) indicates that treatment of shortleaf pine can be deferred (in the Cumberland Plateau) up to two years. Delay results in significant loss of potential growth. Ferguson (1958) and Bower and Ferguson (1968) stress the importance of rainfall to treatment success. Williston and McClurkin (1961) and Zutter, Glover, and Gjerstad (1986) specify soil moisture as one critical element in effecting release.

Several papers report that stands failed to respond to herbicidal release. Speculation as to why there was no response center on damage to the residual trees during application and site characteristics including water relations and competing vegetation onsite (less competition at outset equals less effect from treatment; Campbell 1987; Dierauf 1977; McClay 1955; Ponder and Schlesinger 1984; Russell 1971).

Herbicidal TSI treatment (pine or hardwood stands) to eliminate competing species improves stand vigor and quality (Miller, Wray, and Mize 1987). Haines and Davey (1979) report that in a study to measure growth response (as total loblolly pine biomass produced) the most pronounced treatment effects were obtained with the use of herbicides. Cain (1985a) reported that chemical treatments were more effective than prescribed burning for reducing hardwood density in a stand being managed for pine sawlog production and that the reduction was still evident 23 years after treatments were discontinued. Age of stand (especially for shortleaf pine) is a significant factor in treatment effectiveness; older trees respond less well than younger ones (Williston and Balmer 1980).

Several excellent summary papers are available which contain information about growth effects following herbicidal treatments (Bey and others (1975; hardwoods); Cantrell (1985, general); Gjerstad, Nelson, and Minogue (1984, loblolly pine); Lowery (1986, shortleaf pine); Stewart, Gross, and Honkala (1984, general annotated bibliography); Williston and Balmer (1980, shortleaf pine)).

Species Composition

Broadcast application of a herbicide selective to woody species generally results in a vegetation cover composed of grasses, sedges and forbs. Species resistance to herbicide complicates this generalization. Target specificity of herbicides will influence the species composition of residual vegetation on a site.

Selective applications permit significant manipulation of vegetation. Species which are potential hazards due to height, noxious nature, or other consideration can be selectively controlled. Depending on the selection process, selective stand treatment can be used to favor almost any species.

Sterett and Adams (1977) reported that 3 years after herbicide release treatments pine growth had improved, and, although numbers of some (non-pine) species had declined there was a striking increase in the number of individuals of some species present, as well as the number of species present on the treated area. Scifres and Koerth (1986) report that, though initially affected, diversity and coverage by forbs were virtually unaffected 1 year after tebuthiuron application.

Use of hexazinone to deaden hardwoods, followed within four months by a prescribed fire (brown-and-burn) can be used to thin overstocked pine stands. Nickles, Tauer, and Stritzke (1981) report about 70% reduction in overstocked pine stands in southeastern Oklahoma with complete mortality of smaller diameter (1 inch or less) stems. This effect was greater than that seen on check plots. The additional leaf litter from the deadened hardwood is credited for the increase in fire effectiveness.

In a summary of 41 years of selection management (uneven-aged) in Arkansas, Baker (1986) presents management strategies necessary to regenerate stands and then to maintain stand productivity. In order to permit pine reproduction in these naturally mixed stands and achieve full pine stocking all mid- and over-story hardwoods were initially removed; periodic herbicide treatment was necessary to control understory hardwood; and, annual improvement cuts were needed to remove the poor quality pines and to improve stocking. In order to maintain the stand it was necessary to: (1) periodically control understory hardwoods (herbicides applied at 10-year intervals); (2) continue improvement and harvest cutting on a periodic basis (this was done annually for the first 35 years); and, (3) regulate stand structure by volume control (total volume cut roughly equal to growth since last cut). While selection management did permit gradual improvement in the stocking, accelerated growth of the best trees, and a gradual increase in the proportion of acreage growing high value sawtimber, it also was labor intensive (requiring annual improvement cuts) and also increased herbicide incursion (once every 10 years) in the treatment areas.

Successional Pattern

The chief difference noted between forest and right-of-way sites is frequency of treatment. On forest sites, herbicide treatment is done to temporarily favor a species or group of species at a specific point in its life cycle. Due to physical requirements ROW's are maintained (by repeated management activity) in an early successional stage. Type of plant cover varies greatly depending on the vegetation management technique used (Bramble 1962). Broadcast herbicide application permits maintenance of a low grass, forb and sedge community; more selective application permits maintenance of a slightly taller, shrubby community. For powerline ROW either broadcast or selective treatment may be used. Along roadsides and gas pipeline ROW's broadcast application is generally used to maintain a low-growing, grassy community. However, selective application may be used to favor species such as wildflowers.

There is no evidence that repeated typical applications of a herbicide in ROW settings cause permanent effects on succession. Normal succession resumes within one to three years of last application of herbicide (Bramble and Byrnes 1982).

Information about additional effects of herbicide use in an environment already affected by industrial pollution, agricultural pesticide usage, and automobile emissions is unavailable. Herbicides are applied to individual even-aged stands only one to three times (stand establishment and stand improvement activities) during the 60 or more years they are grown. Herbicide use rates in most Forest Service applications are also very low relative to agricultural or other uses. However, managing uneven-aged stands of pine will require that herbicides be used more frequently to permit establishment of pine reproduction. A 5- to 10-year treatment cycle (which may include fire, manual or mechanical tools) will be necessary (Wenger 1984).

4. Effects of Biological Methods

Cattle grazing can injure or kill vegetation. Grazing also causes changes in plant growth response, and shifts in species composition.

Injury and Mortality

Cattle consume pine and hardwood foliage, and young new shoot and twig growth. Amounts consumed are minor since herbaceous species comprise the bulk of their diet. Plant mortality from direct consumption is low because rootstocks are normally not affected, and most woody and herbaceous species resprout.

Damage to pine and hardwood seedlings occurs from browsing and trampling. In sapling and larger-sized stands, damage occurs from the browsing of lower branches, and by the breaking of lower branches by leaning or rubbing (Lewis, Tanner, and Terry 1987).

Lewis (1980) simulated cattle injury to planted pine and found most mortality occurs 1 to 2 months after an injury. Pearson, Whitaker, and Duvall (1971) found that 80 percent of plant mortality occurs within a few months after planting, and once herbaceous species are available cattle stop browsing the pines. Most planting occurs during the dormant season (December through March) when most herbaceous forage species are unavailable to cattle. The greatest mortality of planted seedlings occurs on heavily grazed sites; light to moderate grazing seedling losses are not significant (Clary 1979; Grelen, Pearson, and Thill 1985; Pearson, Whitaker, and Duvall 1971). Considering that heavy grazing is required to achieve biological vegetation control objectives, significant losses from injury and mortality are expected.

Growth Response

Effects on growth responses are mixed. Pearson, Whitaker, and Duvall (1971) found no significant impact from grazing on growth of seeded or planted pine through 5 years of age. However, measurements taken by Grelen, Pearson, and Thill (1985) on the same site at age 18 showed significantly larger tree diameters on heavily grazed plots compared to ungrazed control plots. Height growth and volume were not affected. Herbaceous forage yields monitored over a 10-year period were not significantly impacted by heavy utilization intensities as high as 60 percent of the current year's growth (Clary 1979; Pearson and Whitaker 1974a, 1974b).

Species Composition

Shifts in species composition occur from heavy grazing. Herbaceous species which comprise the majority of preferred cattle feed are most affected. Grazing can increase forbs and decrease grasses. As grazing intensity increases, species such as pinehill bluestem and panicums decrease and carpetgrass increases (Clary 1979; Pearson and Whitaker 1974a). Woody browse species do not appear to be significantly affected (Clary 1979; Pearson and Whitaker 1974b).

Heavy grazing intensities utilized to achieve site preparation or release objectives when used for more than one or two consecutive growing seasons will change species composition. The longer areas are intentionally overgrazed, the higher the risk of long-term shifts in species composition.

5. Effects of Manual Methods

a. Forest

Injury and Mortality

Manual methods can injure or kill vegetation by completely severing or girdling woody stems. Plants such as most hardwood species and woody shrubs that resprout are usually injured. Plants, such as most pine species, that do not resprout are usually killed.

Non-target vegetation can also be injured or killed when woody shrubs or trees being felled fall onto or cover other stems. Loss of stems selected to remain can be significant. Bernstein (1981) found that 31 percent of conifers in a release project were damaged or covered by slash. A significant risk of injury and mortality in young pine or hardwood plantations exists from the buildup of hazardous fuels from manual release and precommercial thinning projects. This risk is highest for precommercially thinned stands approximately 1 to 6 months after project completion.

Wounds caused by felling woody shrubs or trees onto remaining stems create entry points for insects and disease organisms which may eventually cause stem mortality. In the upper piedmont of Georgia, Miller and Phillips (1984) observed that stumps from chainsaw treatments for hardwood site preparation produce sprouts with higher risk of decay and poorer anchorage than mechanically sheared stumps, because the sprouts originate higher on the stumps and closer to cut surfaces.

Incomplete severing or girdling of target vegetation which does not cause immediate mortality might weaken individual stems and cause mortality several seasons later. A study by Cody and Burns (1976) in New York State showed that a single chain saw girdle was effective in removing unwanted hardwood vegetation (90 percent mortality), but mortality occurred over four growing seasons.

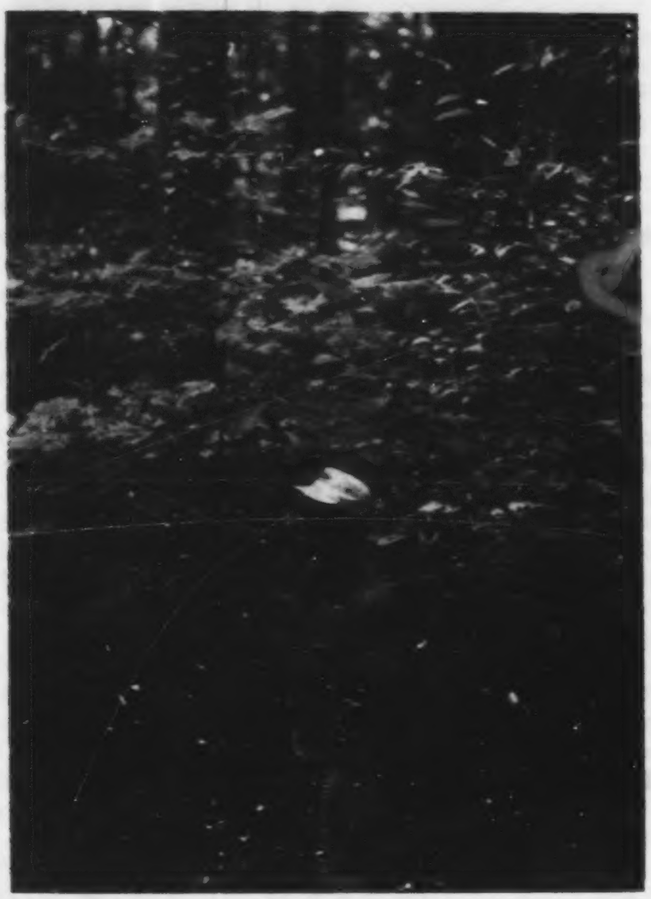
In the Missouri Ozarks, Clark and Liming (1953) compared the sprouting capacity of blackjack oak after two types of bark girdling. The blackjack oaks were either notch or peel girdled 3 feet above groundline. A notch girdle removes the tree bark and extends up to 3/4 of an inch into the trees sapwood, which significantly reduces the water supply to the tree crown; while a peel girdle also removes the bark but extends only approximately 2/10 of an inch into the sapwood and does not restrict all the water supply to the tree crown. In general they found that trees girdled by either method during the growing season resprouted during the same season. Trees with notch girdles died within a few weeks from desiccation but the trees sprouted back below the girdle. With the peel girdle, however, the trees utilized stored food reserves until both the roots and then the crown died off or were severely weakened which resulted in significantly less sprouting. Clark and Liming found that 61 percent of the trees that were notch girdled had viable sprouts while only 46 percent of the peel girdled trees had living sprouts. They also concluded that the lowest amount of sprouting and the highest mortality of sprouts occurred when trees were girdled during June when tree growth is still primarily from stored food reserves, thereby leaving less reserves available for sprout growth.

Phares and Liming (1961) compared the results of shortleaf pine regeneration through direct seeding in the Missouri Ozarks with release treatments during the dormant season (December). Release treatments consisted of manual felling of all trees greater than or equal to 1 inch d.b.h. or by girdling a 3 inch to 6 inch-wide band approximately 3 feet above ground level on all trees greater than or equal tc 1 inch d.b.h. Seedling survival and establishment was greatest on sites which were girdled during the same year as seeding occurred; as opposed to sites where all material was felled during the same year of seeding, or sites that were felled or girdled the year before seeding. Phares and Liming attributed this increased survival to the shade provided by the girdled trees, which reduced seedling mortality from desiccation and also by maintaining lower soil surface temperatures. Sites released the year prior to seeding had reduced survival due to severe competition from herbaceous plants.

Growth Response

Manual cutting tools are highly selective and can be used year round on all landtypes, but repeated treatments, either annually or even more frequently, may be necessary to adequately control woody competition (Lowery 1986). Species which resprout can quickly reoccupy treatment sites, and height growth of sprouts can exceed that of natural and planted seedlings (Miller and Phillips 1984). On moderate to highly productive sites several repeated treatments may be needed to successfully release desired species.

A release treatment in the Missouri Ozarks by Baskett, Dunkeson, and Martin (1957) by girdling all noncommercial tree species greater than 4 inches d.b.h. increased tree reproduction and woody browse species, such as blueberries, sassafras, and New Jersey tea, during the 5 year study period. Grass species such as poverty oat-grass and little bluestem also increased.



When crop-tree release of hardwoods is needed, Smith and Lamson (1983, 1986) and Smith (1979, 1981) recommended manual release when the codominant seedling origin stems are at least 25 feet tall. At that time the potential of tree sprouts to outgrow released crop-trees and the ability of cut grapevines to regrow into tree crowns is reduced.

Rogers and Brinkman (1965) stated that maintaining forest tree growth in the Missouri Ozarks is a common management problem due to the prevalence of shallow, rocky soils with low water storage capacity combined with the occurrence of frequent summer droughts. In their study they found that controlling all hardwood stems through cutting and girdling, followed by foliar herbicide treatment of sprouting hardwoods, increased the growth of thinned and unthinned shortleaf pine by 40 percent over a 10 year period. They also stated that numerous understory hardwoods resulted in a significant reduction of soil moisture and nutrients.

Phares and Rogers (1968), also in the Missouri Ozarks, monitored over a 3 year period the weekly diameter growth rates of natural shortleaf pines in thinned and unthinned stands with and without complete hardwood understory control by manual cutting and girdling and sprout treatment with herbicides. Trees in thinned stands started diameter growth in early April while unthinned stands did not begin growth until early May. This response was attributed to larger tree crown sizes in thinned stands and not from the removal of understory hardwoods. However, they did find that by removing understory hardwoods in thinned stands that the length of the growing period was extended by 3 to 5 weeks; while in unthinned stands the growing period increased by 2 weeks when understory hardwoods were removed. Due to the faster rates of growth, plus the extended growth period, the greatest total growth occurred in stands that were thinned and had hardwood control. The study concluded that increased diameter growth was due to: competition control that reduced moisture stress during summer drought periods, by an extension of the growing period itself, and by faster growth rates.

Long-term effects of manual methods on vegetation are negligible. Sprout growth and crown closure rapidly reoccupy the site.

D. WILDLIFE

Effects of vegetation management on animals can include physical injury or mortality, and short-term and long-term habitat alteration.

Injury and Mortality

Death may result from the effects of herbicides or prescribed fire, or from mechanical, manual, or biological treatments applied to a site when animals are present.

Habitat Alteration

Wildlife habitat is the food, water, cover, and space that an animal needs to survive. Each species is adapted to a unique arrangement of these elements. The distribution of different ecological types and progression of successional stages through time provides these habitats. As habitat changes, so does the variety and abundance of wildlife species.

Vegetation management affects each species' habitat in a different way, benefiting some and harming others. For instance, when natural succession is retarded, species which need early successional stages usually benefit. Vegetation management also affects wildlife when it influences a key habitat element such as food or a place to breed. For example, site preparation may increase or reduce the number of snag trees available for cavity nesting birds. Or numbers of soft-mast producing plants may be reduced by application of herbicides or increased by a mechanical method which encourages sprouting, such as chopping.

Structural diversity of vegetation is probably the most important factor in determining wildlife species composition and abundance (Harris, Hirth, and Marion 1979). Prescribed underburns, for example, alter vegetation structure and composition by reducing woody understories and increasing ground vegetation. This action benefits species such as white-tailed deer (Odocoileus virginianus) by providing more desirable food sources but may degrade the habitat of songbirds like hooded warblers (Wilsonia citrina) which use woody understory.

To keep the effects of vegetation management in perspective, it should be stressed that most vegetation management occurs after habitat has already been substantially altered by timber harvest or regeneration. Silvicultural system (intermediate thinnings, or final harvest; distribution, size, and shape of regeneration areas; rotation age; retention of old-growth), streamside management zones, erosion control, road construction, and other management practices prescribed in Forest Land and Resource Management Plans (and outside the scope of this document) are likely to have a greater impact on wildlife abundance and species composition. Harvest of a mature pine stand, for example, tends to have a more significant effect on wildlife species occupying the site than subsequent site preparation or intermediate treatments which interrupt or accelerate the process of succession.

When vegetation management practices in combination with timber harvest and other management practices are applied in a forest, a variety of vegetation types and structure results. Over time, a mosaic of types is spread across the forest landscape and habitat is provided for many different species of animals. This cumulative effect increases over-all or "among-stand" wildlife diversity even though "within-stand" diversity for a particular site may decrease.

Many treatments using a single tool (pine release by herbicide, for example) which are made only once during a rotation cause few long-term effects. More long-term effects occur when more than one method (such as chainsaw, stump-spray, and prescribed burn) is applied during a single treatment. When this occurs only once in the life of the stand, long-term impacts are not as likely as when stands are treated repeatedly. An example of multiple and repeated treatments is site preparation by KG blade, windrow, and prescribed burn followed by herbicide release at age 3, and prescribed burning on a 5-year cycle beginning at age 10. This sort of periodic treatment is effective in relegating many hardwoods to the understory. These hardwoods may not reach the age or size necessary for mast production or creation of nest cavities. Periodic burning tends to consume snags and downed woody material which provides habitat for reptiles, amphibians and small rodents. However, burning can also result in the creation of new dead material when fire kills trees.

Additional research is needed on the long-term effects on animals associated with plant communities treated with specific combinations of herbicides and periodic fire. Ongoing research and vegetation classification and inventories planned for the Southern Region will help fill some of these gaps.

1. Effects of Herbicides

Source of Information

Information sources for assessing the risk of direct toxic effects to wildlife and aquatic animals are the same as for the human health risk assessment discussed in section B of this chapter. Three sections of the risk assessment apply to the analysis of risk to wildlife and aquatic species:

- Section 6 (the hazard analysis) documents basic toxic properties of the chemicals.
- Section 7 (the exposure analysis) documents probable exposures to these chemicals of terrestrial animals such as mammals, birds, reptiles, and invertebrates; and aquatic animals such as fish, invertebrates and amphibians.
- Section 8 (the risk assessment) combines predicted hazards and exposures, and estimates danger to these animals.

Unless otherwise noted, information presented here is derived from the Risk Assessment (chapter 6-8, appendix A). Literature citations for specific points are found in that appendix.

Hazard Identification

Hazard is evaluated based on dose/time relationships. These relationships and their effects are the same as for human health: acute toxicity, subchronic toxicity, chronic toxicity, mortality, and organ effects.

Exposure and Dose Response

Exposure considerations include where the animal lives, how it moves and feeds, external characteristics of the animal (hair, feathers, scales), rate of herbicide application, size of treatment area, the way the herbicide was applied, and physical characteristics of the herbicide (persistence or drift potential). Exposure is estimated for three different situations:

The **typical** situation (the "realistic" scenarios in the wildlife sections of the risk assessment) estimates the average exposure of terrestrial and aquatic animals that may be reasonably expected during routine operations.

The **maximum** situation ("extreme" scenarios in the wildlife sections of the risk assessment) estimates the worst realistic exposures to terrestrial and aquatic animals when highest rates of herbicide are applied in an area.

An **accident** situation estimates the exposure of terrestrial and aquatic animals which might result from a spill of cans from a truck or a helicopter tank dump into water.

Risk is a function of dose, which is critically dependent on many interrelated factors. Changing any of the factors modeled when predicting risk will change the dose and the potential effects on animal health. Estimates were also made of indirect exposures due to surface, subsurface, or airborne movement of the herbicides and additives in the environment.

Exposure Information

Because toxicological data are unavailable for most species occurring in the Ozark and Ouachita Mountains, a set of species was chosen to represent animals from a variety of habitats and dietary needs. Terrestrial mammals, birds, amphibians, reptiles, and invertebrates, and fish and aquatic invertebrates were selected. Since laboratory tests are not normally done on wildlife species, it was necessary to evaluate several of the representative species by using data for similar animals for which tests have been done.

Herbicide skin contact, inhalation (breathing), and ingestion (eating) are the exposure routes evaluated. Exposure rates were estimated for typical and maximum application rates for ground applications.

The typical setting assumes that animals seek cover during a mechanical application and exposure is limited to contact with and ingestion of herbicide on or in leaves. The maximum case assumes that the animal is sprayed. In both cases, mammals and birds are assumed to ingest herbicide while preening after touching treated vegetation.

In the typical case, the amount of herbicide-contaminated food is taken to be a percentage of the diet (based on the size of the animal's feeding territory). In the maximum case all food is assumed to be contaminated.

Total exposure is estimated by adding exposure by all routes (appendix A, section 7).

Risk Description

Calculations of risk are based on a theoretical dose to animals in each typical, maximum, and accident situation. Risk is evaluated using EPA standards (EPA 1986a). Predicted risk is compared with published standards to see if the herbicide or additive poses a greater or lesser risk. Practices which reduce risk to a level lower than the standard are noted as management requirements or mitigating measures in chapter II.

Inert Ingredients

See discussion in chapter IV, section B.

Data Gaps

When assessing herbicide effects on wildlife, we face an overwhelming number of species with data gaps and inconsistencies in data. Regulatory requirements (40 CFR 1502.22) described in the human health section (Chapter IV, Section B) are addressed in the wildlife risk assessment (appendix A, sections 6-8). Response varies greatly among species, and differences among species are significant even within the same taxonomic grouping such as bird or fish. Ideally, to analyze effects on a species, data should be from tests on that species or a closely related one. Table 8-15 in the risk assessment (appendix A) summarizes data gaps for several species of aquatic animals.

Data gaps which result in uncertainty about reasonably foreseeable significant adverse animal health effects include the following:

- Basic data about acute, subchronic and chronic toxicity are lacking for many animal groups; species-specific information are generally unavailable. Some acute toxicity data are available for mammals but are unavailable for several chemicals for birds, insects, fish, aquatic invertebrates, and amphibians.
- Data on animal exposure to herbicide are generally unavailable. Dermal penetration rates, risk of exposure, and probable rate of exposure are not available.
- Field studies on chemical residue levels in or on plants in treated areas are lacking for most herbicides.

- Carcinogenic and mutagenic potential are unreported for most chemical/animal groupings.
- Data on synergistic effects of herbicides and inert ingredients on wildlife are not available.
- Data on cumulative effects of herbicides on wildlife are unavailable.
- Data concerning relationships between specific chemicals and individual species' habitats are, for the most part, unavailable.

Filling data gaps is a extremely expensive process; individual tests cost between $50,000 (mutagenicity tests, etc.) and $2,500,000 (chronic toxicity tests, oncogenicity tests, etc.). As in the evaluation of human health effects, the Forest Service considers the accumulated costs of filling all of the data gaps prohibitive. Modeling is done to overcome missing or unavailable data.

The analysis of missing and incomplete data is a risk assessment. This approach "is firmly based in scientific considerations... is a process of weighing alternatives and selecting the most appropriate actions" (National Research Council 1983). The risk assessment process provides worst case analyses (maximum and accident scenarios) of reasonably foreseeable scenarios in which extreme exposure to herbicide occurs.

Throughout the analysis, data from tests on similar animals are used to estimate missing or incomplete information. Best conservative estimates were used. For example, a dermal penetration rate of 10 percent was assumed although it exceeds the most rapid rate of skin penetration reported.

a. Direct Effects

Acute Toxicity

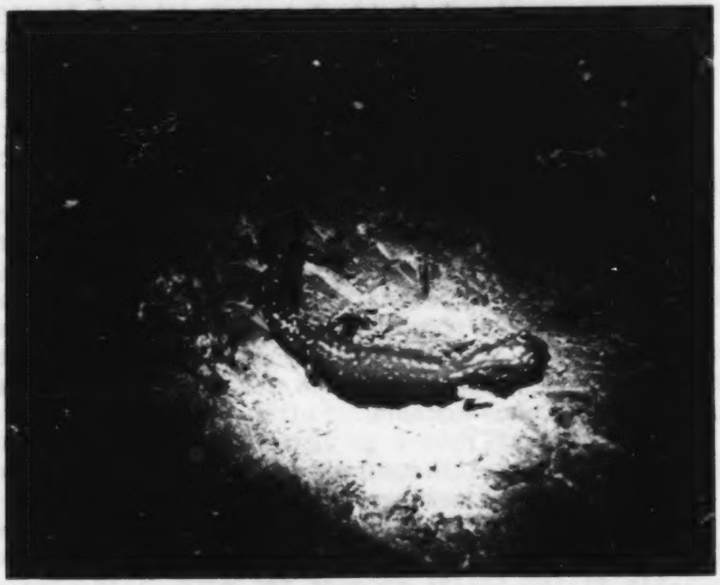
All herbicides evaluated are rated slightly toxic or very slightly toxic to rats when eaten (acute oral toxicity) (appendix A, table 6-1).

Studies of acute oral toxicity in birds, generally mallard duck (Anas platyrhynchos) or bobwhite quail (Colinus virginianus, showed all to be slightly or very slightly toxic. No avian studies were available for limonene.

Diesel oil has been demonstrated to be lethal to chicken embryos at a very low concentration in a single dose (Weeks and others 1988a). At rates significantly higher than normal field application rates, reduced egg viability was demonstrated for fosamine and picloram. This latter information is of concern in the accident scenario. No information was found for hexazinone, imazapyr, mineral oil, sulfometuron methyl, or triclopyr.

Using a scale proposed by Larry Atkins (University of California) all of the herbicides were rated relatively nontoxic (the least toxic category) to honeybees (Apis melliferu). The adjuvants limonene and diesel oil, however, were found to be highly toxic to honeybees. No information is available concerning the toxicity of kerosene to honeybees (appendix A). However, several studies report mineral oil to be toxic to several species of insect (including scale and mites) and also to be synergistic with oil soluble insects (Johnson and Caldwell 1987; Moustafa and El Attal 1985; Ochou, Hesler, and Plapp 1986).

Toxicity data of the seven herbicides for amphibians is classed by EPA as practically nontoxic.



Irritation

In addition to knowing the potential of a chemical to cause death, it is also necessary to know if it is an irritant to skin or eyes. The risk assessment presents data concerning the amount of each chemical which causes primary dermal or eye irritation.

Registration standards required under the Federal Insecticide, Fungicide, and Rodenticide Act were developed for the protection of humans and their environment. For humans a set of four classes has been developed to describe the effects on dermal and eye irritation. This same level of precision is not required for animals. Data presented in this section are for mammals; rats and rabbits are the chief test animals used to determine primary skin and eye effects, and are virtually the only ones tested so far.

Dermal: Dermal irritation was reported (appendix A) as follows:

- None: hexazinone.
- None to slight: glyphosate, imazapyr, and sulfometuron methyl.
- Slight (or mild): Mineral oil, picloram, triclopyr ester, kerosene, and limonene.
- None to moderate: fosamine.
- Slight to moderate: triclopyr amine.
- Extreme: diesel oil.

Dermal exposure to diesel oil at a relatively high rate for three weeks caused death of the test animals. Dermal exposure to kerosene for 28 days at a rate significantly higher than expected in the field resulted in severe skin and liver lesions in rats. At one-half the rate that caused these undesirable effects, (a rate which is still significantly higher than expected in the field), no negative effects were observed (Weeks and others 1988a) due to kerosene dermal exposure.

Eye: Eye irritation was reported (appendix A) as follows:

- None: fosamine (Krenite), diesel oil, and triclopyr ester.
- None to slight: glyphosate, imazapyr, and sulfometuron methyl.
- Slight (mild): kerosene, limonene, and picloram.
- Slight to moderate: none.
- Moderate to severe: fosamine (Krenite S) and triclopyr amine.
- "Irritating": hexazinone.

No Observed Effect Levels

The establishment of NOELs has been done primarily to develop human health guidelines. Animal testing is reported in the section on human health. Data do not exist for groups of animals other than mammals.

Effects of Inert Ingredients

A full discussion of the effects of inert ingredients is presented in the human health risk assessment summary. Kerosene is the only inert ingredient of toxicological concern in herbicides used in the Southern Region.

Acute Effects

The Environmental Protection Agency has published a standard for ecological risk assessment (EPA 1986a). Standards from this publication are used in subsequent discussion.

Terrestrial: The EPA standard for evaluating risk from herbicides and other chemicals to terrestrial wildlife is the comparison of actual dosage with the LD_{50} (the amount of chemical which kills [Lethal Dose] one-half [50 percent] of the test animal population in an acute toxicity test). If the probable dose is less than one-fifth the LD_{50}, it is considered to pose an acceptable level of risk for terrestrial wildlife. Any dose greater than one-fifth of the LD_{50} is considered to pose unacceptable risk for terrestrial animals (EPA 1986a).

The wildlife risk assessment presents the full evaluation of wildlife risk from herbicides applied at normal and extreme rates. Comparison of LD_{50} values with projected dose is presented in tables 8-4 through 8-14 of appendix A. A broad spectrum of animals is evaluated in the analysis; birds (common flicker, bobwhite quail, eastern bluebird, belted kingfisher, American kestrel, and red-cockaded woodpecker), mammals (southern short tailed shrew, red bat, eastern gray squirrel, meadow vole, eastern cottontail, white tailed deer, cotton rat, eastern red fox, black bear, river otter, and bobcat), amphibian (woodhouse toad), reptiles (eastern box turtle, hognose snake, and gopher tortoise), and domestic animals (cow, chicken, and dog). Scientific names are in table 8-35 of appendix A.

Typical Scenario

Results presented in tables 8-4 through 8-14 of appendix A show that the seven herbicides proposed for use and 4 additives applied at typical rates pose less risk than allowed under the EPA standard for wildlife and aquatic animals not listed as threatened or endangered.

Maximum Scenario

Results of modeling maximum rates are mixed. Diesel, oil, fosamine, glyphosate, imazapyr, kerosene, picloram, and sulfometuron methyl pose less risk than allowed by the EPA standard for all animals evaluated. Limonene also posed a lower risk than allowed, but data are unavailable to evaluate its effects on birds, reptiles, and amphibians. Dosage to several mammals is greater than allowable for hexazinone, and triclopyr.

In summary, risk is at a low ("no risk") level, according to EPA standards for terrestrial animals, for all wildlife when typical application rates of herbicides are used. Exceeding typical rates, times, or any other consideration which increases dose can cause a slight to severe level of risk. Several of the herbicides evaluated had low ("no risk") levels of risk at the maximum rate of application, however, several did not.

Chronic and Cumulative Effects

Long-term studies have been performed on mammals to develop information for human health analyses (appendix A). These studies are given in the human health section. Studies evaluating the oncogenic or mutagenic potential of these chemicals on other animals (birds, reptiles, or amphibians) are not currently available. Chronic effects are highly improbable since it is unlikely that terrestrial animals would be exposed more than once in a lifetime from Forest Service activities. Where Forest Service lands border treated private lands, exposure could be more frequent, but still are unlikely to approach levels which could cause chronic health effects in wildlife.

b. Effects on Habitat

Herbicides have an indirect effect on wildlife by altering plant species composition and structure. Depending on the herbicide applied, application rate and method, and vegetation affected, treatments can be detrimental to some wildlife species and beneficial to others. Herbicide effects on wildlife can include an increase in snag availability, or a reduction or increase in hard-mast production, soft mast production, ground vegetation (forbs, grasses), and foliage height diversity (layers of vegetation present within a stand).

Habitat Alteration From Site Preparation

To prepare a site for regeneration, herbicides may be applied alone or in combination with prescribed fire or mechanical treatment. Site preparation may be accomplished by broadcast application or by treating individual stems by injection, thinline, or foliar spray application of herbicides. Sites prepared by herbicide without mechanical treatment support a greater diversity and abundance of bird populations (Darden 1980) because of downed and standing woody material.

When herbicides are applied in bands rather than broadcast over an entire area, deer forage production is slightly higher the first year (Blake, Hurst, and Thomas 1987). Site preparation by herbicides alone results in numerous snags which provide perching sites for raptors (hawks and owls) and potential nest sites and foraging habitat for cavity-nesting and insect-feeding birds. This habitat results in an overall increase of bird diversity in treated clearcuts (Dickson, Connor, and Williamson 1983; Warren, Hurst, and Darden 1984). Removal of shading vegetation may adversely affect reptile and amphibian species, but fallen snags eventually create cover for amphibians and sunning sites for reptiles.

Herbicides used with fire usually result in a stand with sparse ground cover immediately following the treatment. Mourning doves (Zenaida macroura) and small mammals such as cotton rats (Sigmodon hispidus) find early successional stages attractive (McComb and Hurst 1987; Perkins 1973). Production of preferred deer forage can increase for several years following initial reduction after treatment with herbicides such as 2,4-D (Hurst and Warren 1981). Herbicides such as glyphosate reduce grass and herbaceous species the year following treatment but production recovers during the second growing season (Copeland and Hurst 1986).

DeFazio, Stone, and Warren (1988) found that site preparation by broadcasting tebuthiuron pellets followed by burning caused some reduction in woody deer browse but resulted in increased grass, sedge, and forb forage. Their results varied among areas studied and did not indicate that overall impacts on deer were significant but led them to conclude that "... an application rate greater than or equal to 3.1 kg a.i./ha may be inappropriate..."

Habitat Alteration From Pine Release

Treatment of pine stands at 3-6 years of age to control hardwood stems tends to encourage growth of grass, forbs, and vines. This improves conditions for ground-feeding birds, white-tailed deer, and wild turkey (Meleagris gallopavo) by increasing seeds and forage (Hurst and Warren 1986). When applied by broadcast methods, however, these treatments reduce the number of soft-mast producers such as vacciniums and dogwood, which are used by many species of wildlife. Herbicide applications which result in top-kill of hardwoods tend to reduce mast production by relegating many mast-producers to the midstory of the future stand. Root-kill applications cause a more serious reduction by eliminating certain mast-producers altogether. This can have a detrimental effect on deer, turkey, gray squirrels, (Sciurus carolinensis) and many species of songbirds.

Release by selective methods such as spot-around or foliar spray makes it possible to leave individual stems or clumps of mast-producing or other desirable hardwoods. Studies of stands treated with 2,4-D show that retaining even small scattered patches of brush helps maintain bird density and abundance after treatment (Morrison and Meslow 1984b).

The use of herbicides such as glyphosate, which control grasses and herbaceous vegetation, results in temporary reduction in forage. But species composition, total biomass, and forage production are usually similar to untreated areas by the second growing season (McComb and Hurst 1987).

Accelerated growth of pine which results from successful release treatment may benefit some wildlife species because it allows pine stands to be burned and thinned sooner (Owen 1984). Broadcast application of imazapyr increases production of forbs and vines, including important deer forage species like blackberry and dewberry, while reducing woody browse (Hurst 1987).

Habitat Alteration From Stand Improvement

When used for timber stand improvement (TSI), injection of competing hardwood stems in mixed pine-hardwood stands reduces hard and soft-mast production unless selected stems are left. This reduction harms species such as white-tailed deer, gray squirrel, and numerous songbirds. Increased snag availability, however, benefits cavity nesters and small mammals that will use openings created in the stand (McComb and Rumsey 1982). Snags created by herbicides tend to remain standing for a shorter time than those created by other means such as girdling (Conner, Kroll, and Kulhavey 1983). Fruit producing shrubs and vines such as honeysuckle increase, benefiting white-tailed deer and many birds. Increased pine seed production benefits fox squirrels (_Sciurus niger_) and other species.

In the short run and possibly in the long run, bird abundance and diversity increase when some overstory in upland hardwood stands is removed by broadcasting picloram or 2,4-D. The increase is probably due to the resulting increase in the diversity of vegetation layers (McComb and Rumsey 1983; Morrison and Meslow 1984a, 1984b). Habitat for foliage-gleaning birds, however, may be reduced.

Applied selectively for wildlife stand improvement (WSI), herbicides release mast-producing hardwoods and increase mast production for deer, turkey, squirrel, black bear (_Ursus americanus_), and other species. When hardwood midstories are reduced, production of deer forage increases, especially when prescribed fire is also applied (Blair and Feduccia 1977).

Habitat Alteration From Rights-of-Way (ROW) and Openings Maintenance

Wildlife openings and rights-of-way corridors provide early successional stage habitat. Such habitats vary from grass/forb to brush cover depending upon how they are maintained. They also provide transitional zones or "edge," which may increase species diversity. When ROWs transect and fragment large intermediate or mature hardwood stands, some bird species which need large stands to reduce nest parasitism and predation may decline. Although little research exists, naturally created edges (as by wildfire) may reduce this effect compared to abrupt artificial edges (Reese and Ratti in press).

Use of herbicides in wildlife openings maintenance is usually directed at control of persistent non-native grasses such as fescue or control of encroaching hardwood brush. This treatment helps establish native or other grasses, legumes, and forbs. Broadcast application of liquid hexazinone has been used successfully to create wildlife openings for turkey in the Ozark Mountains (Nelson, Hartman, and Leeds [1988]).

Herbicides on ROW corridors may be broadcast or selective. Repeated treatments may result in a low-shrub community which is stable and resistant to invasion by tree species. Such a community develops more rapidly and without the initial loss of brush cover when selective spraying is used (Eaton and Gates 1981). It usually has a substantial soft-mast producing component, and is more beneficial to some small mammals and deer than a grass-forb community (Ladino and Gates 1981). Arner (Mississippi State University, personal communication), however, found that this type of treatment in Mississippi tended to favor sumacs rather than fruit-producers such as vacciniums which are more valuable to many species of wildlife. When shrub cover is patchy and varying in height, a greater diversity of bird species will occur (Kroodsma 1982).

Selective herbicide application to brush or trees that reach a predetermined height results in habitat favorable for white-tailed deer (Bramble, Byrnes, and Hutnik 1985) and some songbirds (Kroodsma 1982; Myers and Provost 1981).

Habitat Alteration From Range Treatment

Herbicides are used alone or in conjunction with other treatments to reduce encroachment of brush on grasslands managed for grazing. Control of brush in small blocks or strips is generally beneficial to deer and turkey. Total control of brush harms many species of songbirds, small mammals, and raptors (Holechek 1981).

2. Effects of Prescribed Fire

a. Direct Effects

Because most animals in the Ozark/Ouachita area are adapted to periodic fires of natural and man-caused origin, direct mortality from prescribed fire has a negligible effect upon animal populations (Lyon and others 1978). Less mobile species such as shedding diamondback rattlesnakes (Crotalus adamanteus) (Means and Campbell 1981) or frogs (Vogl 1973) may occasionally be killed. Most observers, however, indicate that this is rare (Komarek 1969) and that mortality is not normally associated with slow-moving prescribed fires. Furthermore, even fires started by an aerial ignition pattern which results in numerous spot fires rather than linear flame fronts do not result in significant vertebrate mortality (Folk and Bales 1982). A notable exception is the Eastern glass lizard (Ophisaurus ventrali) which may be killed in considerable numbers when prescribed burns are conducted (Means and Campbell 1981).

Larger animals such as white-tailed deer usually move calmly away from advancing fires. There is no evidence that wildlife is harmed by smoke. Raptors, bobwhite quail, turkey, and insectivorous birds are often attracted to recently burned or actively burning and smoking areas (Komarek 1969; Landers 1987; Lyon and others 1978; Stoddard 1963). When burns are conducted during the nesting season, some eggs and young of ground-nesting species are destroyed. Saugey (1988) observed an adult northern fence lizard (Sceloporus undulatus) repeatedly preying on crickets advancing a meter ahead of a slow moving backing fire on a prescribed burn. Although it is possible for direct heating of small streams by fire to result in the mortality of aquatic organisms, mitigation measures do not allow prescribed fires to achieve the intensities or duration necessary for this to occur and any mortality would be restricted to short stretches of water.

b. Effects on Habitat

Lightning-set and man-caused fires have occurred periodically in the Ozark/Ouachita Mountains for several thousand years, animals have adapted to habitats subjected to recurring fires. Some, like bobwhite quail, depend upon fire to maintain their environment (Landers 1987).

Prescribed burning affects different species in different ways. Some effects on wildlife habitats include an increase in the amount, availability, and palatability of forage; changes in production of soft mast; changes in invertebrate populations; and the creation and destruction of snags (Van Lear and Johnson 1983).

Without periodic prescribed burning in most southern pine types, increased fuels increase the occurrence of intense and unplanned wildfires. Habitat alteration from these fires is often severe since overstory vegetation, as well as smaller woody stems, may be destroyed.

A major research need in the area of prescribed fire is the relationship of prescribed fire effects to fire behavior. In other words, how do intensity, duration, and season of burning affect various wildlife species? Data related to effects of burning on many species in the South, particularly songbirds, reptiles, and amphibians, are meager.

Habitat Alteration From Site Preparation

Prescribed fire is used alone or with herbicide or mechanical treatments. Depending upon intensity, broadcast burns may remove very little to virtually all live vegetation and residue. This condition is temporary because roots, bulbs, and dormant seeds are stimulated by fire and soon sprout. Conditions soon become favorable to ground feeders like meadowlarks (Sturnella magna). Deer forage and production of seeds used by birds such as quail increase dramatically, peaking the first or second season after burning (Stransky and Halls 1979b; Warren 1981.) After 2 or 3 years, conditions improve for species such as cottontail rabbits (Sylvilagus floridanus) and cotton rats. Fruits, important to species such as black bear, decrease initially but soon increase (Hamilton 1981).

Site-preparation burning of low-quality upland hardwood stands may improve deer browse availability and make browse available for a longer period following timber harvest (Waldrop, Buckner, and Muncy 1985). However, available browse was not used except near the edge of clearcuts. But when Appalachian hardwood clearcuts are burned following timber harvest, logging slash and debris used by hairy and downy woodpeckers is destroyed (Conner and Crawford 1974).

Habitat Alteration From Stand Improvement

Prescribed underburns are carried out in pine and pine-hardwood stands ranging from saplings to mature stands. Whether they are used to improve conditions for wildlife or range, reduce hazardous fuels, or control competing vegetation, their effects on wildlife are similar. Effects vary, however, according to season, intensity, and frequency of burns. In the Ozarks burning in August resulted in a 47% increase in forbs while burning in June resulted in a slight decrease in forbs (Lewis, Murphy and Ehrenreich 1967).

Burning has long been used as a tool in the southern pine types to improve white-tailed deer habitat. Research indicates that nutrient content (particularly protein and phosphorous) and palatability of deer food increase temporarily after burning. Effects on deer browse from wildlife or fuel-reduction burns applied at 3-5 year intervals may be small and short-lived (Wood 1988). Fruit yields of understory shrubs decrease immediately, then increase to levels higher than before burning and decline gradually. Optimum fruit production probably occurs when pine stands are burned every three years (Johnson and Landers 1978). In addition, deer browse decreases initially, but increases rapidly for several years afterward (Blair and Enghart 1976; Hurst and Warren 1982; Stransky and Harlow 1981). Browse after burning generally grows out of the reach of deer after 4-5 years (Landers 1987). Repeated burns, particularly during the growing season, may reduce the amount of woody vines such as honeysuckle, an important deer food (Landers 1987). Consequently, protecting some areas from burning is important.

Periodic dormant-season burning of scattered areas probably benefits black bear because it increases production of some fruits (Hamilton 1981). Prescribed burning benefits most fur-bearers because fire increases prey abundance and availability. Burns also increase production of fruits such as blackberry and blueberry. Production of important foods such as persimmon and grapes, however, may decline (Johnson and Landers 1978; Miller and Speake 1978).

Many small mammals need the early successional forest stages created or maintained by fire. Long-term studies indicate that rodents such as the eastern harvest mouse (Reithrodontomys humulis) and hispid cotton rat, which feed on seeds and grass, usually increase after prescribed fire. Insectivorous mammals like short-tailed shrews (Blarina brevicauda) tend to decrease (Landers 1987). Other (short-term) studies have shown immediate reductions of mice and rats accompanied by increases of shrews (Fala 1975; Landers 1987). When fire is used to control hardwoods in pine stands, it generally has a negative impact on squirrels since it reduces future production of acorns. Fire may be beneficial to fox squirrels, however, when it is used to maintain low-growing oak species or promote a lush groundcover which provides escape cover (Hillard 1979). Habitat will generally remain suitable for squirrels as long as scattered patches of mast-producing hardwoods remain interspersed in pine stands (Landers 1987). Prescribed fire, particularly patchy burning done annually or biennially, appears to be beneficial to rabbits (Hill 1981).

Annual or biennial dormant-season burning for quail is a common management tool. Most managers agree that fire should be excluded from some areas to provide 2-3 year old roughs necessary for nesting cover and soft-mast production (Hurst 1981; Landers 1981; McRae and others 1979). Burning for management of wild turkey is also common, although it is generally conducted on a longer (3-5 year) rotation than burns for quail management. Benefits include increases in legumes, reduction in external parasites, maintenance of brood habitat for poults, and increases in the arthropod food supply. Early growing season burns or burning less frequently than every 5 years may reduce lespedezas and other legumes important as food sources for quail and turkey (Lewis and Harshbarger 1976, 1986; Speake 1966). Decline in hard-mast, important for turkey, squirrels, and many other species, may result from repeated burning.

Effects, resulting from prescribed burns, on songbirds can vary greatly depending on the birds' habitat needs. Prescribed fires may eliminate standing dead trees that provide cavity nest sites. However, fires also kill trees, thus providing sites for new cavities (Conner 1981). According to Dickson (1981), burning increases early successional species such as Bachman's sparrow (*Aimophila aestivalis*) and birds such as pine warblers (*Dendroica pinus*) which inhabit intermediate to mature pine stands. Species such as the hooded warbler and black-and-white warbler will be less abundant in stands where burning has reduced the hardwood midstory. When variations in fire behavior result in patchy vegetation, bird diversity tends to increase (Landers 1987).

Periodic burning helps to temporarily provide open conditions. Such conditions make hunting of small mammals and birds by hawks easier, and tend to attract many species of predatory birds. Red-tailed hawks (*Buteo jamaicensis*), kestrels (*Falco sparverius*), and loggerhead shrikes (*Lanius ludovicianus*) often feed in freshly burned areas (Komarek 1969).

Little research exists on fire effects on reptiles and amphibians in the South. Prescribed burning may be beneficial for some frog species by maintaining grassy wet habitats. Without fire these areas develop into brushy hardwood areas, eliminating the water and grass environment (Komarek 1969). Means and Moler (1979) has recommended the use of prescribed burning to reduce tranpiration by hardwoods encroaching on pine barrens treefrog (*Hyla andersoni*) habitat.

Habitat Alteration From ROW and Openings Maintenance

Prescribed fire is not commonly used in the Ozark/Ouachita Mountains as a means of managing vegetation in and ROWs. Limited research indicates that compared to openings mechanical or herbicide treatments, dormant-season burning produces more arthropods and insects for birds to feed on (Hurst 1970) and may produce more legumes and other plants used by birds like quail (Huntley and Arner 1981).

Habitat Alteration From Range Treatments

Prescribed burning for range produces responses similar to those of stand improvement burns. In addition to improving forage quantity and quality for cattle, range burns improve browse conditions for deer. In longleaf pine-bluestem range, burning also lessens competition between cattle and deer by reducing the amount of diet overlap between the species (Thill 1982).

3. Effects of Mechanical Methods

a. Direct Effects

Mechanical methods occasionally cause direct mortality of adult animals or result in destruction of eggs or young. Normally, vertebrate species are able to flee in advance of equipment and escape harm, although some reptiles and amphibians may be killed. Mowing, chopping, shearing, raking, disking, and other mechanical tools cause some direct mortality to invertebrates, but, because of large populations and high reproductive rates, populations are not hurt. Destruction of eggs and young depends upon season of treatment and can occur when equipment is used during the nesting season.

Disturbance caused by equipment used for site preparation may result in abandonment of young or nests. With larger vertebrates such as deer or rabbits, such abandonment is normally temporary. Ground-nesting birds may permanently abandon nests if disturbance occurs soon after nesting begins but will tolerate greater disturbance when eggs are close to hatching. Although most ground-nesters will renest, survival rates for young from late-season nesting attempts are generally lower.

b. Effects On Habitat

Specific research on the effects of mechanical treatments on many species is scarce. Fortunately, since data regarding the effects of mechanical treatments on vegetation structure and species composition are available, conclusions regarding effects on wildlife can be made. In some ways, effects are similar to those resulting from herbicide or fire, but vary depending on the degree to which root stocks are destroyed.

Habitat Alteration From Site Preparation

As with prescribed burning, most mechanical site preparation treatments increase the number of plant species and amount of herbaceous ground cover as compared with uncut, mature forest stands. More intensive mechanical methods, however, such as raking reduce the number of woody fruit-producers (Stransky and Halls 1980; Stransky and Roese 1984; Swindel, Conde, and Smith 1984).

Small seed-eating mammals that use early successional habitat benefit more from mechanical site preparation if windrows, scattered brush cover, and downed logs are not removed (as by burning) (Buckner and others 1979). Rabbits and many reptiles and amphibians benefit as well. Short-term (up to age 5) increases in deer forage following mechanical treatments can be dramatic. Chopping, which does not destroy plant root systems, generally results in higher browse production than more intensive methods (Stransky and Halls 1979b). Sites prepared by bedding seem to attract fewer rabbits than do sheared or chopped sites (McKee 1973).

When intensive mechanical treatments such as shear, rake, and windrow are used in conjunction with burning, soft-mast species such as blackberry and pokeweed soon invade (Campo and Hurst 1980). These open sites attract ground feeders such as mourning doves the first year following treatment. As more cover becomes available (2-3 years), species such as bobwhite quail utilize the site. Turkey use the areas for nesting cover as well. Retaining windrows also increases use by species such as house wrens (Troglodytes aedon) (Rowse and Marion 1981). With all site preparation methods, retention of snags greatly increases use by cavity nesters and raptors.

Based on limited research, it appears that intensive treatments which remove debris reduce the numbers of reptiles and amphibians. However, intensive treatments may provide habitat for tree-dwelling reptiles sooner than less-intensive treatments. A patchy distribution of habitats allows for more rapid recolonization after treatment (Enge and Marion 1985).

Habitat Alteration From Other Stand Treatments

Use of mechanical treatments for other purposes is minor. Effects are similar to those discussed in the preceding section. Chopping for pine release helps species such as deer by opening strips in dense stands, thus increasing production of forbs and legumes.

Habitat Alteration From ROW and Openings Maintenance

Mowing is the primary mechanical method for maintaining ROWs and wildlife openings. Mowing maintains a grassy groundcover which can provide nesting and bugging habitat for turkey, and cover for several species of rodents. Frequent mowing, however, reduces cover for species like cotton rats and ground-nesting birds (Schmidly and Wilkins 1977). Less-frequent mowing and strip mowing benefits most wildlife species found in ROWs because such practices leave islands of cover for nesting and escape.

Light disking is sometimes used to break-up grass cover and encourage native legumes, which are an important food for ground-feeders like quail.

4. Effects of Manual Methods

It is unlikely that manual methods cause any direct mortality except when removal of brush or trees destroys nests or young. Human disturbance may cause temporary or permanent abandonment of young or nests. Losses are minor and can be reduced if workers resist the temptation to "rescue" apparently orphaned animals. Normally, disturbance is short-lived, as workers move on to untreated areas and animals return. Effects on habitat are similar to those described for mechanical techniques which do not disturb the soil.

Selective hand-cutting of trees underneath overhead wires and cutting of tall trees along ROW edges helps maintain bird species diversity better than treatment by aerial broacast herbicide or periodic mowing (Bramble, Byrnes, and Schuler 1986).

5. Effects of Biological Methods

Insignificant direct mortality occurs when livestock trample nests or the young of ground-nesting birds. Also, there is a potential for transmission of diseases such as epizootic hemorrhagic disease (which affects deer) from livestock to wildlife populations.

Heavy year-round grazing reduces quality of habitat for many wildlife species. Research indicates, however, that light to moderate cattle grazing generally has little adverse impact on seed-producing plants important to ground feeders (Lewis and Harshbarger 1986). Short periods of intense grazing tend to reduce grasses and increase forbs eaten by deer and turkey (Moore and Terry 1979) and tend to improve bobwhite quail habitat (Schulz and Guthery 1988).

E. THREATENED, ENDANGERED, PROPOSED, AND SENSITIVE SPECIES

Introduction

The generalizations regarding effects of vegetation management on wildlife presented in section D also apply to species listed as threatened, endangered, proposed, and sensitive. Procedures required in chapter II, including site-specific biological evaluation and environmental analysis, are designed to ensure that these species are protected when vegetation management projects (including those designed to benefit the species) take place. Forest inventories, Forest Land and Resource Management Plans, recovery plans, and Forest Service Handbook chapters are also important.

For some other species, particularly those adapted to a disturbance-related environment, use of vegetation management techniques such as prescribed burning to mimic natural disturbances is essential for continued species viability. The red-cockaded woodpecker, for example, requires open pine stands without a hardwood midstory. Prescribed fire on a 2-3 year rotation will maintain habitat that is already suitable. Herbicide, manual or mechanical treatments, or growing season burns are required to control hardwood stems larger than 2 inches and restore habitat suitability to colony sites with encroaching hardwoods (FSH 2609.23R R8 AMEND 13).

As discussed in chapter II, recovery plans and Forest Service Handbook chapters have been prepared for several threatened, endangered, and proposed species. With some of these species, factors such as poaching or loss of critical habitat outside of national forests combine to hinder species recovery. Recovery plans and handbook chapters consider these factors when establishing guidelines for Forest Service practices which may affect threatened, endangered, and proposed species.

There is a need for recovery plans and handbook chapters to be prepared for each of these species in the Southern Region and for each national forest to prepare guidelines for protecting and managing sensitive species occurring on the forests.

General effects of vegetation management methods on threatened, endangered, proposed, and sensitive species are presented in tables D-1 through D-6 in appendix D (the biological evaluation for this document). Measures to mitigate these effects are presented in appendix D and in chapter II.

1. Effects of Herbicides

Terrestrial Species

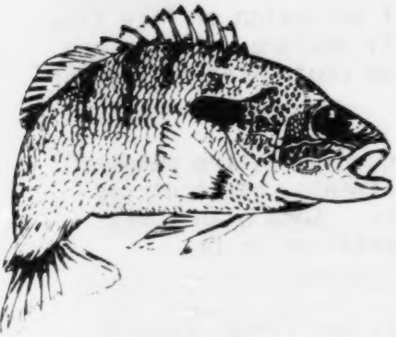
The EPA standard for chemical exposure considers a dose of less than 1/10 LD_{50} as not presenting a significant risk for a threatened or endangered terrestrial species. Based on toxicity data and exposure predictions made in the risk assesment, most of the herbicides analysed do not present a significant risk to any threatened, endangered, or proposed species when applied at typical rates. Significant risk exists from exposure of the Indiana and gray bat to triclopyr.

If applied at maximum rates, hexazinone and triclopyr present a significant risk to most of the threatened, endangered, and proposed species listed in table III-5 and most of the sensitive species listed in III-7.

Low toxicities, low risk of exposure, and mitigation measures (detailed in chapter II) governing the use and handling of herbicides, combined with requirements for site-specific inventories and environmental analysis, make the probability of direct toxic effects on threatened, endangered, proposed, or sensitive animals low. Key mitigation measures include a restriction on application at greater than typical rates and limitations on use of herbicides identified in this chapter as posing significant risk. Many of the sensitive plant and animal species are endemic (restricted in distribution to relatively small or specific areas) and occur on lands and in timber types not suitable for timber procuction or most vegetative management activities.

Aquatic Species

The EPA standard for theatened, endangered, or proposed aquatic animals identifies an exposure of greater than 1/20 LC$_{50}$ as presenting a significant risk. Based on predictions regarding exposure of the representative species analysed in the risk assessment to two accidental spill scenarios, the endangered fat pocketbook pearly mussel faces a significant risk from a spill of diesel oil, the Roundup formulation of glyphosate, kerosene, limonene, sulfometuron, and the ester formulation of triclopyr.



An accidental spill of these chemicals poses a significant risk to the following sensitive species as well: Arkansas darter, crystal darter, longnose darter, paleback darter, Caddo madtom, Ouachita madtom, Arkansas fat mucket mussel, Neosho mucket mussel, Western fan-shelled pearly mussel, paddlefish, Kiamichi shiner, Ouachita Mtn. shiner, and peppered shiner.

Mitigating measures in chapter II regarding the transportation, handling, and application of herbicides are designed to make the likelihood of such an accidental spill very small.

Plant Species

Threatened, endangered, proposed, and sensitive plant species can be extremely sensitive to the effects of herbicides and direct treatment can destroy a local population. If the population is isolated, as many are, there may be no means for natural reestablishment. Response varies depending on several factors. Dicamba, for instance, might kill Alabama snow-wreath or Ouachita hedyotis, both woody plants, but have little effect on a herbacoues species like Moore's delphinium. Stem injection of hardwoods with picloram would not threaten a nearby population of maple-leaf oak, whereas foliar spraying might. Although risk is lower when a herbicide has low efficacy for controlling a particular plant species, all of the herbicides analyzed are toxic to any plant when applied at sufficient rates, and are considered to pose a significant risk to all threatened, endangered, proposed, and sensitive plants occurring in the Ozark/Ouachita Mountains. This risk may be mitigated by conducting site-specific inventories and environmental analysis and by carefully selecting chemical, rate, method and season of application (see chapter II).

Sensitive plants may benefit, however, when herbicides are used to control competing vegetation, providing that non-target species are not inadvertently damaged by the application.

2. Effects of Prescribed Fire

Some plant species may be stimulated by fire, particularly those occurring on slopes with south aspects beneath a pine or pine-hardwood overstory, and in glades and other open areas. Species occurring in mesic and very wet conditions, such as woodland acid seeps and stream channel borders where the natural occurrence of fire is a rarity, should be protected. Several species are associated with habitats that are created or maintained by fire. For example, without periodic burning, habitat for the red-cockaded woodpecker, becomes unsuitable. Past exclusion of fire from this species' habitat has hastened its decline. Season and intensity of burning, however, must be controlled to prevent habitat damage.

3. Effects of Mechanical Methods

Most threatened, endangered, proposed or sensitive plant species are harmed by mechanical treatments, particularly those techniques that disturb the soil. Some plants may benefit by release from competing vegetation or be stimulated to reproduce.

As with burning, mechanical treatments may either harm or benefit these species. Falcons, red-shouldered hawks, and migrant loggerhead shrikes, for example, may benefit from treatments such as chopping (combined with herbicide application or burning). These treatments provide for grass-forb early seral stage conditions and may enhance hunting activities by these species. However, animals such as terrestrial salamanders may be harmed by soil-disturbing treatments like heavy disking.

4. Effects of Manual Methods

Manual treatments are less likely than mechanical treatments to be harmful to threatened, endangered, proposed, or sensitive plants since they do not disturb soil or root systems. Most woody species will respond by resprouting, but others may be killed if treated directly.

5. Effects of Biological Methods

Some species, such as those found in open timber stands and in disturbed areas along roadways, may respond favorably to light grazing. However, many sensitive plant species are found on mesic north slopes, in riparian areas adjacent to streams, seeps and springs, and in unusual plant communities where grazing is unlikely to provide any benefits. In these situations grazing damages habitat by causing soil compaction, and may result in excessive damage to plants due to trampling.

F. SOIL

Introduction

Productivity, a site's ability to grow vegetation over time, depends on physical, chemical, and biological qualities of the soil. Productive soils have loose and porous structure, ample reserves of organic matter and nutrients, and balanced populations of small organisms.

Sensitivity to disturbance varies with soil fertility. Poor soils such as severely eroded soils are infertile (low in organic matter and nutrients) and highly sensitive. Fair soils such as shallow inceptisols and partly eroded soils are intermediate in fertility and moderately sensitive. Good soils are fertile and slightly sensitive (table IV-9).

Table IV-9.--Distribution of soil fertility classes in the various landtypes*

	--------Percent of Landtype-------		
Landtype	Poor	Fair	Good
OUACHITA PROVINCE			
Arkansas Valley	--	19	81
Ouachita Mountains	1	16	83
OZARK PLATEAUS PROVINCE			
Springfield Plateau	1	20	79
Boston Mountains	1	25	74
COASTAL PLAIN PROVINCE			
St. Francis Unit	1	--	99
Tiak Unit	--	11	89

*See Figure IV-4, section G (Water) for map of landtypes

1. Effects of Prescribed Fire

Prescribed fire has both favorable and adverse effects on soil. Favorable effects are temporarily enhanced nutrient availability and phosphorus cycling and reduced soil acidity. Adverse effects are caused by soil heating, soil erosion, and nutrient leaching. Soil heating can kill soil biota, alter soil structure, consume organic matter, and remove site nutrients during the burn. Soil erosion and nutrient leaching occur during later rainstorms and cause smaller nutrient losses (appendix B).

There are three types of prescribed fire: (1) slash burns in harvested stands; (2) underburns beneath stands; and (3) grassland burns. Effects on soil vary with type of burn.

Slash burns are a site preparation tool used to regenerate harvested stands. They typically occur every 40-80 years in pine stands and every 60-120 years in hardwood stands. Risk of adverse effects depends mostly on fire severity, which is defined by ground condition after the burn (Wells and others 1979) and differs from fire intensity. An intense slash burn done when duff, soil, and larger fuels are moist will seldom be severe (Van Lear and Danielovich 1988).

Underburns occur every 3-7 years and are usually light to moderate in severity. Adverse effects from a single burn are minimal. Risk of adverse effects from repeated burns depends mostly on their frequency and season of use.

Like underburns, grassland burns occur every 3-7 years and are light to moderate in severity. Risk of adverse effects depends mostly on frequency of burn.

Soil Heating

Light slash burns scorch the litter and duff on most of the area. Soil heating has little effect on soil biota, structure, or organic matter. Less than 150 lb/ac of nitrogen is released as gas from slash, litter, and duff. Effects on other soil nutrients (phosphorus, potassium, calcium, magnesium) are favorable (appendix B).

Moderate slash burns char and partly consume the litter and duff on most of the area. Soil biota are reduced but recover quickly. Soil structure is not affected. Much litter and duff may be consumed, but soil organic matter is little affected. Between 300 and 350 lb/ac of nitrogen may be released as gas from slash, litter, duff, and topsoil. Other soil nutrients are little affected (appendix B).

Severe slash burns consume all litter and duff and alter the color and structure of mineral soil on most of the area. Destruction of soil biota sterilizes the site and full recovery takes years. Soil porosity, infiltration, and moisture capacity are reduced. About 90 percent of litter and duff and 50 percent of topsoil organic matter are often consumed. Between 650 and 850 lb/ac of nitrogen may be released as gas from slash, litter, duff, and topsoil. Large amounts of phosphorus may also be lost (appendix B).

Underburns more frequent than every 3 years do not affect soil biota, but litter-duff biota are reduced and do not fully recover before the next burn. Loss of organic matter exceeds 10 percent. Nitrogen loss may be up to 160 lb/ac for dormant season burns and 600 lb/ac for growing season burns. Annual underburns also impair soil porosity and infiltration (appendix B).

Underburns every 3-4 years allow litter-duff biota to fully recover between burns. Soil physical properties are not affected. Loss of organic matter is about 5 percent. Nitrogen loss may be 100-150 lb/ac for dormant season burns and 400-450 lb/ac for growing season burns (appendix B).

Underburns every 5 years or more have little effect on biota and soil structure. Organic matter increases by about 5 percent. Nitrogen loss may average 90 lb/ac for dormant season burns and 240 lb/ac for growing season burns (appendix B).

In grasslands, most biomass and nutrients are below ground. Nutrient loss is less harmful than in forests. Annual burns, however, pose high risk to soil productivity via reduced litter biota, impaired soil porosity and infiltration, and reduced organic matter. Risk is minimal for cycles of 3 years or more (appendix B).

Soil Erosion

Effects of prescribed fire on soil erosion depend on fire severity. Severe slash burns can cause serious erosion, because they expose mineral soil on much of the area and recovery may take 3 years. Moderate burns cause minor erosion, because they expose soil on less than 20 percent of the area and recovery usually takes 1 year. Light burns cause no erosion because they expose almost no soil (Dissmeyer and Stump 1978). Underburns and grassland burns are usually light to moderate, so their effect on erosion is generally negligible (appendix B).

Potential erosion is estimated by the Universal Soil Loss Equation (USLE). USLE computes potential erosion to increase with greater rainfall energy, soil erodibility, and slope length and steepness; and to decrease with greater ground cover provided by vegetation, litter, rock, and fine roots (Dissmeyer and Foster 1984). Average values of rainfall, soil, and slope factors for the various landtypes (Dissmeyer and Stump 1978) are shown in table IV-10.

Table IV-10.--Average values of USLE factors for the landtypes

			USLE Factors		
Landtype	Slope Steepness (Percent)	Slope Length (Feet)	Rainfall	Soil Erodibility	Slope/ Length
OUACHITA PROVINCE					
Arkansas Valley	15	150	300	0.32	3.15
Ouachita Mountains	20	100	320	0.32	4.10
OZARK PLATEAUS PROVINCE					
Springfield Plateau	20	180	260	0.28	5.49
Boston Mountains	20	150	280	0.32	5.02
COASTAL PLAIN PROVINCE					
St. Francis Unit	20	110	320	0.37	4.30
Tiak Unit	2	100	325	0.24	0.20

Effects of fire on ground cover were estimated from many field observations in the South (Dissmeyer and Stump 1978) as modified by erosion research (Blackburn, Wood, and DeHaven 1986; Brender and Cooper 1968; Cushwa, Hopkins, and McGinnes 1971; Douglass and Van Lear 1983; Goebel, Brender, and Cooper 1967; Miller 1984; Ursic 1969, 1970). USLE's cover factor is estimated at 0.000 for light burns, 0.002 for moderate burns, and 0.015 for severe burns. Potential erosion in the various landtypes (appendix B) is shown in table IV-11.

Table IV-11.--Potential erosion (tons per acre) for treatments by landtype

Landtype	Mod. Burns Herbicides	Chop-Shear Pile	Rake and Severe Burns	Disk*
OUACHITA PROVINCE				
Arkansas Valley	0.60	0.91	4.54	9.73
Ouachita Mountains	0.84	1.26	6.30	8.48
OZARK PLATEAUS PROVINCE				
Springfield Plateau	0.80	1.20	6.00	8.08
Boston Mountains	0.90	1.35	6.75	9.09
COASTAL PLAIN PROVINCE				
St. Francis Unit	1.02	1.53	7.64	10.30
Tiak Unit	0.03	0.05	0.23	0.94

*Erosion for disking would be greater on all but the St. Francis and Tiak units if mitigation measures did not require contour disking limited to average slopes of 10 percent.

Nutrient Leaching

Leaching losses from prescribed fire depend on fire severity. Nitrogen is often mobilized in the topsoil after fire by infiltration and fixation. Some is leached through the soil and into streams. Losses of nitrogen may be 1 lb/ac for light burns, 3 lb/ac for moderate burns, and 20 lb/ac for severe burns. Losses of other, less mobile nutrients are negligible. Underburns do not cause significant leaching losses because nutrients are retained through uptake by unburned plants (appendix B).

Long-term Effects

Nitrogen budgets (table IV-12) show that timber harvest followed by light slash burns produces positive nitrogen budgets and allows long-term nitrogen buildup. Moderate burns produce neutral nitrogen budgets. Severe burns produce negative nitrogen budgets and cause long-term nitrogen depletion; losses over one timber rotation amount to 21 percent of site total in poor soils, 16 percent in fair soils, and 14 percent in good soils (appendix B).

Table IV-12.--Cumulative nitrogen budgets (lb/ac) for pine stands on 60-year rotations

	Light Burns	Moderate Burns	Severe Burns	Piling
LOSSES				
Harvested Stems	140	140	140	140
Slash Removal	28	55	99	99
Litter Removal	100	200	360	200
Soil Heating*	-	60-105	220-385	-
Soil Displacement*	-	-	-	-
Soil Erosion#	-	4	27	5
Leaching	61	63	80	63
TOTAL	329	522-567	926-1091	507
INPUTS				
Atmospheric	300	300	300	300
Plant Fixation	100	100	100	20
Other Fixation	200	200	200	180
TOTAL	600	600	600	500
NET BUDGET				
Poor Soils	+271	+78	-326	-7
Fair Soils	+271	+57	-403	-7
Good Soils	+271	+33	-491	-7

*Nitrogen lost varies with soil nitrogen content.
#Erosion values used are average values for Boston Mountains.

For dormant season underburns every 3-7 years, long-term nitrogen loss may be 3-5 percent of site total in fair and good soils and 6-8 percent in poor soils. Losses for growing season underburns every 5-7 years may be 7 percent in good soils, 8 percent in fair soils, and 13 percent in poor soils. Losses for growing season underburns every 3-4 years may be 12 percent in good soils, 15 percent in fair soils, and 22 percent in poor soils (appendix B).

Overall Risks

Long-term effects on nitrogen are combined with effects on soil biota, physical properties, and organic matter to judge overall risk to soil productivity. Risk of light slash burns is minimal on all soils. Risk of moderate slash burns is minimal on good and fair soils, and low on poor soils where they prevent long term soil recovery. Risk of severe slash burns is extreme on poor and fair soils, and high on good soils.

Risk to soil productivity from underburns depends on their frequency and season. For 5+ year underburns, risk from dormant season burns is minimal on good and fair soils and low on poor soils, while risk from growing season burns is low on good and fair soils and medium on poor soils. For 3-4 year underburns, risk from dormant season burns is minimal on good and fair soils and low on poor soils, where they prevent long-term soil recovery, while risk from growing season burns is medium on good and fair soils and extreme on poor soils. For 1-2 year underburns, risk from dormant season burns is medium on good soils, high on fair soils, and extreme on poor soils, while risk from growing season burns is extreme on all soils.

Mitigating Impacts

Severe burns are avoided by conducting slash burns so they do not consume all litter and duff and alter structure and color of mineral soil on more than 20 percent of the area. One way to achieve this result is to schedule slash burns one to three days after a soaking (0.5 inch or more) rain when soil, duff and large fuels are moist. In addition, poor soils can be protected by not burning any area with an average litter depth of less than 1/2 inch. For 3-4 year underburns, risk to soil productivity from growing season burns can be reduced to low on good and fair soils and high on poor soils by alternating them with dormant season burns. Mitigation measures required to protect soil from prescribed fire are on page II-47.

Data Gaps

Data are lacking on effects of severe slash burns on soil in the South. Underburns have been extensively studied, but studies of slash burns have been limited to light to moderate burns. Severe slash burns are analyzed as posing high to extreme risk to soil productivity, so data on their effects are important. The Council on Environmental Quality (CEQ) mandates a process for evaluating incomplete and unavailable information (40 CFR 1502.22).

To provide complete information, slash burns must be studied repeatedly on an array of poor, fair, and good soils in the South. The burns must be strictly controlled to produce severe effects. Such a comprehensive research program would cost several hundred thousand dollars and require 10 years or more. The Forest Service views these costs as too high to justify delay of this EIS.

The CEQ regulations require that existing credible evidence be summarized and impacts be analyzed using accepted methods. Existing data on effects of slash burns on soil are summarized in Appendix B. The method used to analyze impacts is:

1. Data on soil heating were compiled from slash burns in the Pacific Northwest and Australia and chaparral burns in the Pacific Southwest. These data were adjusted for southern burning conditions.

2. Data on effects of soil heating on organic matter and nitrogen were compiled from laboratory studies and the above field studies. These relationships were applied to typical levels of organic matter and nitrogen found in poor, fair, and good soils in the South to estimate degree of risk to soil productivity.

2. Effects of Mechanical Methods

Mechanical methods may affect soil productivity through nutrient displacement, soil compaction, soil erosion, and nutrient leaching.

Nutrient Displacement

Nutrient displacement is the movement of organic matter and nutrients offsite by dozer blades. Slash, litter, duff, and topsoil are moved into piles or windrows that occupy 5-10 percent of the site. Nutrients contained in the moved material are effectively lost to the site (Neary, Morris, and Swindel 1984). Raking moves nearly all litter and duff and up to two inches of topsoil, while piling moves only slash and some litter and duff.

Estimates of nitrogen lost by raking that moved 1 inch of topsoil range from 430 to 760 lb/ac (Burger 1979; Burger and Pritchett 1988; Neary, Morris, and Swindel 1984; Tew and others 1986; Tuttle, Golden, and Meldahl 1985). Burned windrows where about 0.5 inch of soil had been moved still had nitrogen contents of 230-330 lb/ac, despite large gaseous losses caused by burning (Morris, Pritchett, and Swindel 1983; Pye and Vitousek 1985). Large reductions in site pools of phosphorus, potassium, calcium, and magnesium were also reported. Reductions of nitrogen in litter and duff have ranged from 75 to 95 percent (Fox, Burger, and Kreh 1986; Morris and Pritchett 1983).

Raking may improve early stand growth by temporarily making nutrients more available and reducing competition. But later stand growth and long term soil productivity are reduced by nutrient deficiencies (especially of nitrogen and phosphorus) because organic matter that supplies nutrients over time is displaced offsite (Banker, Miller, and Davis 1983; Burger and Crutchfield 1986; Burger and Kluender 1982; Burger and Pritchett 1988; Pritchett and Morris 1982; Wells 1983). Growth losses of 20-50 percent have been measured in stands where 0.5-2.0 inches of topsoil had been removed before planting (Brendemuehl 1967; Dissmeyer 1985; Fox, Morris, and Maimone 1985; Haines, Maki, and Sanderford 1975; Pritchett 1981; Wilhite and McKee 1985).

Piling is estimated to move 90 percent of slash, 50 percent of litter and duff, and no soil from the site. Effects on site organic matter are minor and short term. About 300 lb/ac of nitrogen and 25 lb/ac of phosphorus might be removed.

Raking is estimated to move 90 percent of slash, litter and duff, and 0.4 inch of topsoil from the site. Major, long-term reductions of site organic matter occur. About 650-850 lb/ac of nitrogen and 35-40 lb/ac of phosphorus may be removed. Removal of potassium, calcium, and magnesium is 15-25 percent of site total.

Soil Compaction

Soil compaction is caused by the weight of machinery on the ground. It increases bulk density and decreases aeration porosity. Bulk density of undisturbed topsoil is commonly 1.00-1.20 g/cc; as it climbs to 1.40 g/cc, root growth is inhibited (Gent and Ballard 1985; Simmons and Ezell 1983). Aeration porosity (soil volume in pores larger than 0.05 mm) reflects a soil's ability to store and supply air, water, and nutrients. In undisturbed topsoil, it is commonly 20-25 percent. When it drops below 10 percent, root growth is restricted (Baver, Gardner, and Gardner 1972). Compaction also reduces populations of soil biota, with recovery taking 3-5 years (Smeltzer, Bergdahl, and Donnelly 1986).

Compaction is most severe in the top 3 inches of soil. It rarely occurs below 6 inches in harvest areas, can reach to 12 inches in major skid trails, and is negligible below 12 inches (Burger and others 1985). Compaction in skid trails exceeds threshold levels of bulk density (1.40 g/cc) and aeration porosity (10 percent) throughout the top 12 inches (Gent, Ballard, and Hassan 1983; Gent and others 1984; Gent and Morris 1986). Severe compaction in roads, skid trails, and log decks has been found to reduce volume of young pine stands by 50-70 percent (Hatchell, Ralston, and Foil 1970; Kreh, Burger, and Torbert 1985; Mitchell 1979; Perry 1964). It may take 20-40 years for severely compacted soils to recover (Perry 1964; Wells and Morris 1982).

Compaction hazard depends on soil type and moisture. Sandy soils do not have a plastic limit; they do not have enough clay to be compacted at any moisture level (Portland Cement Association 1973). Loamy and clay soils can be seriously compacted when soil moisture exceeds their plastic limit (Hatchell, Ralston, and Foil 1970; Moehring and Rawls 1970). The plastic limit varies from soil to soil, but is exceeded more of the time in clay soils and in floodplain and toeslope soils that receive extra moisture from upslope. Compaction hazard is highest for these soils and minimal for sandy soils.

Compaction hazard also depends on ground cover and number of machine passes. Slash, litter and duff buffer the soil against vehicle pressures. Compaction increases with number of machine passes, although most is caused by the first three passes and little occurs after 10 passes (Burger and others 1985; Hatchell, Ralston, and Foil 1970; Kreh, Burger, and Torbert 1985; Moehring and Rawls 1970; Simmons and Ezell 1983). Compaction hazard is less for methods that remove little slash, litter and duff and require 1-2 passes than for those that remove much litter and duff and require several passes.

Studies of compaction by mechanical methods in the South are limited to chopping, raking, disking, and bedding. Chopping rarely increases bulk density or decreases aeration porosity (Blackburn, Wood, and DeHaven 1986; DeWit and Terry 1983; Gent, Ballard, and Hassan 1983; Gent and others 1984; Gent and Morris 1986; Morris and Pritchett 1983; Pehl 1984; Slay and others 1987; Stransky 1981). Changes are limited to the 0-3 inch soil depth. Bulk density increases average less than 0.05 g/cc and never approach 1.40 g/cc. Aeration porosity declines by 0-3 percent. Compaction by mowing, ripping, shearing, and scarifying, which also remove no organic material and require only 1-2 passes, is also minimal. Ripping reduces compaction in the furrows.

Raking, which removes litter and duff and involves several passes, commonly increases bulk density and decreases aeration porosity (Blackburn, Wood, and DeHaven 1986; DeWit and Terry 1983; Gent and Morris 1986; Morris and Pritchett 1983; Pehl 1984; Slay and others 1987; Stransky 1981; Tuttle, Golden, and Meldahl 1985). Changes are limited to the 0-3 inch soil depth. Bulk density increases average 0.15 g/cc and may reach 1.40 g/cc. Aeration porosity decreases by 5-6 percent and may drop below 10 percent. Raking may reduce rainfall infiltration by 50-80 percent (Banker, Miller, and Davis 1983).

Disking restores bulk density and aeration porosity in the 0-3 inch soil depth (Gent and others 1984). It should eliminate the shallow compaction caused by harvest and site preparation. Disking to at least 12 inches is required to eliminate the deep compaction on skid trails (Hatchell 1981).

Bedding restores bulk density and aeration porosity in the beds (DeWitt and Terry 1983; Gent, Ballard, and Hassan 1983). It should effectively mitigate the shallow compaction caused by harvest and site preparation. Beds must be at least 12 inches high to mitigate the deep compaction on skid trails (Gent Ballard, and Hassan 1983; Hatchell 1981). Bedding is not done in the Ozark/Ouachita Mountains.

Harvest may increase bulk density by 0.10 g/cc and decrease aeration porosity by 3-5 percent in the 0-3 inch soil depth (Gent, Ballard, and Hassan 1983; Gent and others 1984; Gent and Morris 1986). Mowing, chopping, shearing, and scarifying are estimated to increase bulk density by 0.03 g/cc and decrease aeration porosity by 2 percent. Piling, which removes most slash and some litter and duff, is estimated to increase bulk density by 0.10 g/cc and decrease aeration porosity by 4 percent.

Given pre-harvest values of 1.00-1.20 g/cc for bulk density and 20-25 percent for aeration porosity, risk of exceeding threshold bulk density or aeration porosity is minimal for mowing, chopping, ripping, shearing, and scarifying, and low for piling. Disking effectively mitigates compaction from harvest and site preparation.

Heavy equipment is not allowed on loamy or clay soils when the water table is within 12 inches of the surface or when soil moisture exceeds the plastic limit. This mitigation measure (page II-51) reduces risk from compaction in harvest areas to minimal for piling.

Soil Erosion

Mechanical methods can cause soil erosion by exposing and tilling soil. Mowing exposes almost no soil, and ripping and scarifying increase surface storage, so these tools cause negligible erosion (Miller, Beasley, and Lawson 1988c). Chopping, shearing, and piling expose little soil and cause minor erosion. Disking exposes and tills the most soil and causes the most erosion.

The effect of mechanical methods on ground cover was estimated from Dissmeyer and Stump (1978) as modified by erosion research (Beasley 1979; Beasley and Granillo 1985a, 1985b; Beasley, Granillo, and Zillmer 1986; Blackburn, Wood, and DeHaven 1986; Blackburn and others 1987; Douglass and Goodwin 1980; Pye and Vitousek 1985). USLE's cover factor is estimated at 0.000 for mowing, ripping, and scarifying;

0.003 for chopping, shearing, and piling; and 0.060 for disking. Disking requires 3 years for recovery, while the other tools require only 1 year. Potential erosion is shown in table IV-11.

Nutrient Leaching

Leaching losses from mechanical methods increase with degree of site disturbance (Blackburn, Wood, and DeHaven 1985; Fox, Burger, and Kreh 1986; Hollis, Fisher, and Pritchett 1978; Morris, Pritchett, and Swindel 1983; Riekerk 1983; Vitousek and Matson 1984). Potential nitrogen losses may be 3 lb/ac for chopping, scarifying, ripping, shearing, and piling and 20 lb/ac for disking. Losses of other, less mobile nutrients are negligible.

Long-term Effects

Nitrogen budgets (table IV-12) show that timber harvest followed by piling produces neutral nitrogen budgets. Nitrogen losses from other tools are negligible, less than 40 lb/ac.

Overall Risks

Effects on nutrient pools and soil compaction are combined to judge overall risk to soil productivity from mechanical methods. Risk is minimal for mowing, chopping, ripping, shearing, scarifying, and disking. Risk of piling is minimal on good and fair soils, and low on poor soils where it prevents long-term soil recovery.

3. Effects of Herbicides

Effects of herbicides on soil are summarized by Neary and Michael (appendix C). Herbicides addressed in this EIS have no known effect on soil physical and chemical properties. Herbicides may affect soil productivity through biotic impacts, soil erosion, and nutrient leaching.

Biotic Impacts

Depending on application rate and soil environment, herbicides can stimulate or inhibit soil organisms. Adverse effects are observed only at concentrations well above those found in forestry field studies. Use at lowest effective rate required by mitigation measures (page II-51) does not reduce activity of soil biota (Fletcher and Friedman 1986; Greaves and Malkoney 1980). These herbicides are not general biocides but are formulated strictly to affect the more complex metabolic processes of higher plants that are absent in microflora (appendix C).

Soil Erosion

Herbicides do not disturb soil, so treated areas usually have intact litter and duff that maintain erosion at low levels (appendix C). Selective treatments do not expose soil. Bare soil after broadcast treatments rarely exceeds 15 percent (Neary, Bush, and Grant 1986); USLE's cover factor is estimated to be 0.002 with recovery taking 1 year. Potential erosion from broadcast treatments is shown in table IV-11.

Pye and Vitousek (1985) found that broadcasting herbicides after raking and disking suppressed revegetation and produced 2.6 times the erosion of raking and disking alone. This effect was not noted after chopping, where litter and duff remained essentially intact. Broadcasting herbicides after disking or severe slash burns, which expose mineral soil over most of the area and rely on revegetation to reduce erosion, should at least double erosion from these practices.

Nutrient Leaching

Nutrient leaching after herbicide use has been little studied. Based on nitrate losses found by Neary, Bush, and Douglass (1983), nitrogen losses from broadcast treatments are less than 10 lb/ac due to suppression of vegetation uptake. Losses of other, less mobile nutrients are negligible.

Overall Risks

Nitrogen losses from erosion and leaching should not exceed 14 lb/ac. Nitrogen budgets over a timber rotation are positive and allow long-term nitrogen buildup. Overall risk to soil productivity from herbicides is minimal.

4. Effects of Biological Methods

Grazing can affect soil compaction, erosion, and nutrients. Degree of impact varies mostly with intensity of grazing.

Soil Compaction

Compaction hazard from grazing depends on soil type and moisture, ground cover, and grazing intensity. Light to moderate grazing increases bulk density of topsoil by only 0.05-0.08 g/cc even when combined with burning every 3 years, and 1.40 g/cc is not approached. Light to moderate grazing combined with annual burning increases bulk density by 0.10-0.15 g/cc (Suman and Halls 1955). Aeration porosity declines by 0-4 percent. Heavy grazing (overgrazing) increases bulk density by 0.10-0.25 g/cc, often beyond 1.40 g/cc. Aeration porosity declines by 8-15 percent and may drop below 10 percent.

Heavy grazing in the Blue Ridge Mountains reduced hardwood growth by 25-50 percent due to compaction. Removing livestock rectifies effects of overgrazing within 3 years (Blackburn 1984; Johnson 1952; Patric and Helvey 1986; Suman and Halls 1955; Wood and others 1987).

Harvest may increase bulk density by 0.10 g/cc and decrease aeration porosity by 3-5 percent in topsoil. Given pre-harvest values of 1.00-1.20 g/cc for bulk density and 20-25 percent for aeration porosity, risk from post-harvest grazing of exceeding threshold bulk density (1.40 g/cc) or aeration porosity (10 percent) is minimal for light to moderate grazing and high for overgrazing. Biological control for pine release requires heavy grazing; risk to soil productivity from compaction is rated as low, since grazing lasts one season and effects last only 3 years.

Soil Erosion

Erosion rates from grazed land in the East range from 0.01 to 1.01 tons/ac/yr, but seldom exceed 0.30 tons/ac/yr with light to moderate grazing (Patric and Helvey 1986). In Texas grasslands, bare soil after 28 years of grazing occupied 0-3 percent of the area studied for light grazing, 6 percent for moderate grazing, and 25 percent for heavy grazing (Blackburn 1984). In Louisiana rolling uplands, moderate grazing increased erosion on plots from 0.05 to 0.07 tons/ac (Wood and others 1987).

The effect of heavy grazing on ground cover was estimated from Dissmeyer and Stump (1978). USLE's cover factor is given a value of 0.006. Potential erosion ranges from 0.09 tons/ac in the Tiak unit to 2.70 tons/ac in the Boston Mountains.

Soil Nutrients

Moderate grazing may slightly increase nitrogen and phosphorus in topsoil (Wood and others 1987). Nutrient leaching from grazing in the South has not been studied. Nitrogen leaching from heavy grazing is estimated to be 10 lb/ac. Losses of other, less mobile nutrients are negligible.

Nitrogen losses from erosion and leaching should total less than 21 lb/ac. Nitrogen budgets over a timber rotation are positive and allow long-term nitrogen buildup. The impact of biological methods on soil nutrients is minimal.

5. Effects of Manual Methods

Effects of manual methods on soil are negligible. Litter and duff are left intact and revegetation is not suppressed. Risk of physical, chemical, or biological change is minimal.

G. WATER & AQUATIC LIFE

Introduction

Water quantity and quality can be changed by actions on the land. The degree of change determines the severity of effects on aquatic life. A key water quantity concern is the size and frequency of stormflows. Water quality is the physical, chemical, and biological purity of water. Even in undisturbed forests, floods occur and water is never pure. Concerns arise when channel stability, aquatic habitat, or water use is impaired.

Aquatic life includes fish and the plants and animals that form a complex food web. The energy for this food web is supplied by organic matter delivered to or produced in the water. In streams shaded by riparian vegetation, the main sources of organic matter are terrestrial leaves, branches, humus, and insects. In rivers, lakes, and ponds more exposed to the sun, the major sources are aquatic plants, plankton, and decomposing plant material.

Water quantity effects are analyzed as stormflow increases. In general, the references cited in this section show that increases in total water yield are roughly proportional to increases in stormflow volume, especially in watersheds where most water yield occurs as stormflow. They also show that such increases are small and short-lived except where intense mechanical tools, severe slash burns, or heavy grazing is used. These intensive tools generally increase stormflow but not baseflow because, in addition to reducing plant water use, they expose soil, reduce infiltration, and promote surface runoff.

Water quality effects are analyzed as increases in chemicals (herbicides, nutrients), sediment, and bacteria in water. The size of these increases depends greatly on use of mitigation measures (section II.E).

1. Effects of Herbicides

Herbicides applied to the land may unintentionally enter surface or ground water. Herbicide use may also increase stream nutrients, stormflows, and sediment yields.

Surface Water

Entry of herbicides to surface water is discussed in the Risk Assessment (appendix A) and by Neary and Michael (appendix C). Herbicides may enter streams during treatment by direct application or drift, or after treatment by surface or subsurface runoff. To pollute water, they must occur at concentrations high enough to impair water quality for human use or injure or kill aquatic plants or animals.

Direct application of herbicides to surface water occurs when streams are accidently overflown during aerial application. Risk is highest on utility lines where flight paths cross many streams, and less in timber stands where flight paths are laid out to avoid streams. Peak concentrations depend mostly on application rate and degree of overflight, and have commonly been 2.100 to 2.400 ppm in field studies where overflight was substantial (appendix C). This agrees with a recent field study of glyphosate (Payne, Feng, and Reynolds 1987). Concentrations drop below 0.050 ppm onsite within 1-2 days and decrease rapidly downstream due to mixing and dilution. But some aquatic plants and animals may be injured or killed onsite.

Drift of herbicides into surface water depends mostly on application method, existence of buffers, and weather. Drift occurs only in foliar applications, is greater for broadcast than selective treatments, increases from hand to mechanical to aerial tools, and decreases from small to large droplets to granules. Drift increases with wind, but buffers moderate its effects. Peak concentrations in streams from aerial spraying of fine droplets with 50-70 foot buffers have commonly been 0.130 to 0.148 ppm in field studies (appendix C). Mitigation measures (section II.E) require application of granules or large droplets in favorable weather, using clearly marked buffers of 100 feet (aerial) and 30 feet (ground), so peak concentrations from aerial drift should rarely exceed 0.050 ppm (appendix A). Applying glyphosate as large droplets by air with an 82-foot buffer produced a peak concentration of only 0.002 ppm (Payne, Feng, and Reynolds 1987).

After treatment, herbicides may enter streams by subsurface flow or by movement in ephemeral channels. Key factors affecting peak concentration are presence of buffers, storm size, herbicide application rate and properties (mobility and persistence), and downstream mixing and dilution.

Perennial and intermittent streams are protected by 30-foot (ground) and 200-foot (aerial) buffers. Herbicides applied along these streams must move through the buffer and are subject to dilution and mixing in transit. If ephemeral streams are not buffered, herbicides applied directly to them are usually picked up in streamflow by the first storm large enough to create flow in the channels.

Large storms rarely produce high herbicide concentrations in streams because herbicides are diluted by large water volumes. Small storms may not produce enough flow to move herbicides into streams. Intermediate storms produce the highest concentrations (appendix C).

Potential herbicide concentration in streams is proportional to application rate. Lowest effective rates required by mitigation measures (page II-51) are 0.1-4.0 lb/ac except for fosamine and are a fraction of the label rate. Selective treatment further reduces rates by 40-70 percent.

Herbicide mobility and persistence affect potential entry to streams. Herbicide mobility depends on water solubility and adsorption (soil bonding) tendency. Of herbicides studied in this EIS, the potentially most mobile are picloram (high solubility, low adsorption) and hexazinone (moderate solubility, minimal adsorption). Conversely, sulfometuron methyl and triclopyr have minimal solubility and fosamine and glyphosate are extremely adsorptive (appendix C, table 1).

Herbicide persistence depends on modes and rates of degradation. Picloram and glyphosate are moderately persistent (half-life 2 months). Picloram degrades mainly by direct sunlight and microbial degradation is slow. Glyphosate degrades mainly by microbial action but not by sunlight. Conversely, persistence of fosamine and sulfometuron methyl is minimal (half-life 10 days) due mainly to rapid microbial degradation (appendix C, table 1).

Based on mobility and persistence, the studied herbicides with the most potential for subsurface movement to streams through buffers are picloram and hexazinone. In field studies where herbicides were applied at lowest effective rates using typical buffer widths, peak concentrations in streams have been less than 0.050 ppm (appendix C).

Herbicide mobility has less effect on levels of herbicides in ephemeral streams if buffers are not used and herbicides are applied directly to the channel. Persistence is important because it determines how much herbicide is still present in the channel when the next flow-producing storm occurs. Herbicides can be mobilized in solution or with sediment. Peak concentrations in field studies have ranged from 0.180 to 0.550 ppm (appendix C).

Dilution by water inflow and mixing by turbulence rapidly reduce herbicide concentrations downstream. As watershed size doubles, peak herbicide concentration should drop to 1/4 its initial level (Neary, Bush, and Douglass 1983). For example, a peak concentration of 0.500 ppm in an unprotected ephemeral stream with a 10-acre watershed will likely drop to 0.050 ppm by the time it reaches a small perennial stream with a 50-acre watershed and 0.001 ppm in a large stream with a 2,500-acre watershed.

Mitigation measures (page II-57) require buffers along perennial and intermittent streams, and mixing and dilution rapidly reduce concentrations delivered by unbuffered ephemeral streams. Peak concentrations of some herbicides in small, headwater perennial streams due to drift or runoff may range up to 0.050 ppm in some cases. Even if we apply EPA's strictest drinking water standard (0.100 ppm for 2,4-D) to all herbicides studied in this EIS, these concentrations pose minimal risk to water quality for public health or aquatic plants and animals. For example, 0.926 ppm of hexazinone do not affect aquatic algae, invertebrates, or fish (Neary, Bush, and Douglass 1983). Since picloram affects many vegetable crops at concentrations as low as 0.010 ppm (Baur, Bovey, and Merkle 1972), it should be used with care near water used for irrigation.

Accidental direct application to streams occurs on some aerial treatments, especially utility lines. Risk to water quality is generally minimal where mixing and dilution are substantial, as in municipal watersheds whose reservoirs exceed 5 acre-feet.

Wetlands, Rivers, and Estuaries

Effects on wetland vegetation are minimal because buffers keep herbicide concentrations below 0.050 ppm. Mixing and dilution reduce herbicide concentrations to 0.001 ppm long before they reach rivers or estuaries, so effects on them are negligible.

Effects on Aquatic Animals

Appendix A discloses acute, chronic, and cumulative herbicide effects on aquatic animals. Studied chemicals with at least moderate acute toxicity to fish, amphibians, or invertebrates are diesel oil, glyphosate (Roundup), kerosene, limonene, picloram, and triclopyr ester (appendix A, pages 6-15 to 6-42). Toxic risk of herbicide concentrations is rated as nil for less than 0.1 LC_{50}, slight for 0.1-0.5 LC_{50}, and significant for more than 0.5 LC_{50} (EPA 1986a). Tables IV-13 and IV-14 show toxic risk to selected aquatic animals resulting from accidental spills of herbicides.

Risk of **acute toxicity** from drift or runoff of any chemical is nil. Risk from an accidental spill is slight for sulfometuron methyl and significant for diesel oil, glyphosate (Roundup), kerosene, limonene, and triclopyr ester. No risk results from accidental spill of the other chemicals (appendix A, tables 8-17 to 8-33).

Data on **chronic toxicity** to aquatic animals are limited. Data on one species exist for sulfometuron methyl and triclopyr. Risk of chronic effects, such as reproduction or long term survival, were estimated for combinations of species and herbicides with sufficient data. No significant risk was identified.

Cumulative effects occur only if a herbicide accumulates in the body. The studied herbicides show no such tendency (appendix A, table 3-4), and risk from cumulative exposure should not exceed other risks addressed in appendix A due to mixing, dilution, and rapid degradation. Herbicide mixtures used on national forests have not shown synergistic effects.

Ground Water

Entry of herbicides to ground water is discussed in the Risk Assessment (appendix A) and by Neary and Michael (appendix C). After treatment, herbicides may move into aquifers by vertical seepage. To pollute ground water, they must occur at concentrations high enough to impair water quality for human use. Key factors affecting peak concentration are herbicide application rate and properties (mobility and persistence) , soil type, depth to water table, and distance to point of use.

Potential herbicide concentration in ground water is proportional to application rate. As discussed earlier, lowest effective rates are a fraction of the label rate and selective treatment further reduces rates by 40-70 percent.

Herbicide mobility and persistence affect potential for seepage. Mobility depends on solubility and adsorption, and persistence depends on degradation mode and rate. As discussed earlier, the potentially most mobile herbicides are picloram and hexazinone and the most persistent ones are picloram and glyphosate. Mobility and persistence properties suggest that herbicides with at least a moderate seepage potential include hexazinone, imazapyr, and picloram.

Table IV-13.--Risk of exposure of fish and aquatic animals from an accidental terrestrial spill of herbicide or adjuvant. Terrestrial spill is assumed to be an amount equal to that carried in a a single container in a pickup truck (5 gal (19 l)). All chemical is assumed to reach the water (a pond). NR = No risk (according to the EPA standard) dose is less than 1/10 LC_{50}; SL = Slight risk (can be mitigated), dose between 1/10 and 1/2 LC_{50}; ■ = Severe risk, dose is larger than 1/2 LC_{50}; — = No information available.

	DIESEL	POSAMI	GLYPHO RODEO	GLYPHO ROUNDU	HEXAZI	IMAZAP	KEROSE	LIMONE	PICLOR +2,4-D
Rainbow trout	SE	NR	NR	SE	NR	NR	SE	SE	NR
Brook trout	SE	NR	NR	SE	NR	NR	SE	SE	NR
Largemouth bass	SE	NR	NR	SE	NR	NR	SE	SE	NR
Smallmouth bass	SE	NR	NR	SE	NR	NR	SE	SE	NR
Bluegill	SE	NR	NR	SE	NR	NR	SE	SE	NR
Green sunfish	SE	NR	NR	SE	NR	NR	SE	SE	NR
Pathead minnow	SE	NR	NR	SE	NR	NR	SE	SE	NR
Gizzard shad	SE	NR	NR	SE	NR	NR	SE	SE	NR
Northern hogsucker	SE	NR	NR	SE	NR	NR	SE	SE	NR
Mosquitofish	SE	NR	NR	SE	NR	NR	SE	SE	NR
Chain pickerel	SE	NR	NR	SE	NR	NR	SE	SE	NR
Crayfish	SL	NR	—	NR	NR	—	NR	—	—
Water flea	—	NR	NR	SL	NR	NR	—	—	NR
Stonefly nymph	—	—	—	SL	—	—	—	—	NR
Virignia oyster	—	—	—	—	NR	—	—	—	NR
Mudpuppy	—	—	—	—	—	—	—	—	NR

	SULFOM	TRICLO AMINE	TRICLO ESTER
Rainbow trout	SL	NR	SE
Brook trout	SL	NR	SE
Largemouth bass	SL	NR	SE
Smallmouth bass	SL	NR	SE
Bluegill	SL	NR	SE
Green sunfish	SL	NR	SE
Pathead minnow	SL	NR	SE
Gizzard shad	SL	NR	SE
Northern hogsucker	SL	NR	SE
Mosquitofish	SL	NR	SE
Chain pickerel	SL	NR	SE
Crayfish	NR	NR	—
Water flea	SL	NR	—
Stonefly nymph	—	—	—
Virignia oyster	—	NR	—
Mudpuppy	—	—	—

Table IV-14.--Risk of exposure of fish and aquatic animals from an accidental aerial spill of herbicide or adjuvant. Spill is assumed to be an emergency helecopter tank-dump of 100 gal (379 l). All chemical is assumed to reach the water (a resevoir). NR = No risk (according to the EPA standard) dose is less than 1/10 LC_{50}; SL = Slight risk (can be mitigated), dose between 1/10 and 1/2 LC_{50}; ■ = Severe risk, dose is larger than 1/2 LC_{50}; — = No information available.

	DIESEL	FOSAMI	GLYPHO RODEO	GLYPHO ROUNDU	HEXAZI	IMAZAP	KEROSE	LIMONE	PICLOR +2,4-D
Rainbow trout	SL	NR	NR	SL	NR	NR	SE	NR	NR
Brook trout	SL	NR	NR	SL	NR	NR	SE	NR	NR
Largemouth bass	SL	NR	NR	NR	NR	NR	SE	NR	NR
Smallmouth bass	SL	NR	NR	NR	NR	NR	SE	NR	NR
Bluegill	SL	NR	NR	NR	NR	NR	SE	NR	NR
Green sunfish	SL	NR	NR	NR	NR	NR	SE	NR	NR
Fathead minnow	SL	NR	NR	NR	NR	NR	SE	NR	NR
Gizzard shad	SL	NR	NR	SL	NR	NR	SE	NR	NR
Northern hogsucker	SL	NR	NR	SL	NR	NR	SE	NR	NR
Mosquitofish	SL	NR	NR	SL	NR	NR	SE	NR	NR
Chain pickerel	SL	NR	NR	SL	NR	NR	SE	NR	NR
Crayfish	NR	NR	—	NR	NR	—	NR	—	—
Water flea	—	NR	NR	NR	NR	NR	—	—	NR
Stonefly—ymph	—	—	—	NR	—	—	—	—	NR
Virignia oyster	—	—	—	—	NR	—	—	—	NR
Mudpuppy	—	—	—	—	—	—	—	—	NR

	SULFOM	TRICLO AMINE	TRICLO ESTER
Rainbow trout	NR	NR	SL
Brook trout	NR	NR	SL
Largemouth bass	NR	NR	SL
Smallmouth bass	NR	NR	SL
Bluegill	NR	NR	SL
Green sunfish	NR	NR	SL
Fathead minnow	NR	NR	SL
Gizzard shad	NR	NR	SL
Northern hogsucker	NR	NR	SL
Mosquitofish	NR	NR	SL
Chain pickerel	NR	NR	SL
Crayfish	NR	NR	—
Water flea	NR	NR	—
Stonefly—ymph	—	—	—
Virignia oyster	—	NR	—
Mudpuppy	—	—	—

Herbicides move most easily through sand, which is most porous and has the least adsorption potential. Potential for ground water contamination increases as depth to water table and distance to point of use decrease.

The Risk Assessment (appendix A) models herbicide contamination of ground water under conditions likely to produce high concentrations. Herbicides are applied at maximum rates to the soil surface. They are then leached through 3 feet of sandy loam soil by 50-60 inches of annual rainfall. The water table is only 3 feet deep, and the aquifer is sand. In the model, only hexazinone, imazapyr, and picloram reach the shallow water table even 10 percent of the time. Concentrations in ground water directly under the treated area exceed 0.001 ppm only for hexazinone (0.004). No herbicide moves outside the treatment area.

Field studies show that, applied at lowest effective rates required by our mitigation measures (page II-53), sulfometuron methyl and triclopyr do not seep to shallow ground water, and hexazinone and picloram should reach peaks of less than 0.024 ppm (appendix C).

Theoretically, risk of ground water contamination in karst areas is higher because herbicide entry may occur in concentrated runoff through sinkholes or bedrock fissures. To reduce this risk, herbicides may only be applied selectively (directly to individual plants) on rock outcrops or sinkholes (page II-57). This mitigation lowers their effective application rate and their availability for surface or subsurface runoff. Given these constraints, and the fact that dilution in karst systems is very high, herbicides in karst ground water should not exceed concentrations in shallow sand aquifers (0.025 ppm). Effects on karst aquatic biota should be minimal.

Applied at lowest effective rates, herbicides should not occur in shallow ground water at concentrations exceeding a small fraction of EPA's strictest drinking water standard. Deeper aquifers tapped by wells should have negligible concentrations. Risk to ground water quality is minimal, especially since mitigation measures (page II-57) require a buffer around all water sources that reduces herbicide concentrations through mixing and dilution.

Some herbicides used in agriculture have been found in ground water. However, the potential for ground water contamination is many times greater in agriculture than on national forests for two reasons:

1. In agriculture, herbicides are usually broadcast at label rates, which are 3 to 50 times the rates allowed on national forests by our mitigation measures (page II-53).

2. In agriculture, herbicides are often applied 3 times per year. On national forests, they are applied once or twice every 40 to 120 years for timber growth and once every 5 years for general wildlife and range habitat. In the general forest, all studied herbicides are fully degraded long before the next treatment.

Figure IV-3 shows relative onsite loading of a herbicide with a 30-day half-life used in agriculture (3 times per year) versus national forests over a 5 year period. Many times more herbicide resides onsite and is available for leaching to ground water in the agricultural site than in the forest.

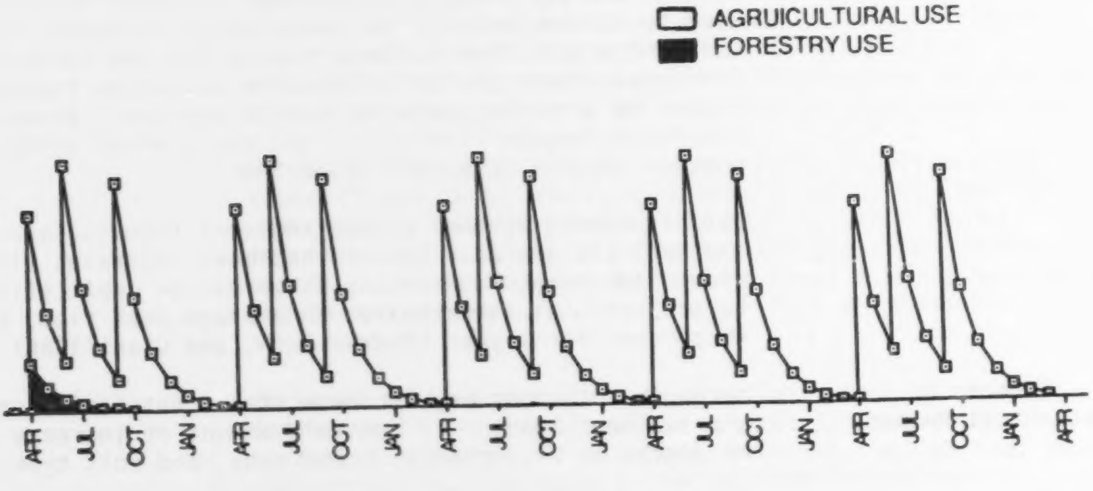


Figure IV-3.--Relative onsite loading of a herbicide with a 30-day half-life used in agriculture (at label rate) versus national forests (at 1/4 label rate) over a five-year period.

Stream Nutrients

Broadcast use of the studied herbicides at lowest effective rates may produce minor increases in stream nutrients such as nitrates. Increases are short-lived due to minimal soil disturbance and prompt plant regrowth. Drinking water standards are not exceeded if mitigation measures (section II.E.2.c) are employed (Neary, Bush, and Grant 1986). Increases are less where treatments are selective or streams are buffered.

Stormflows

Effects of low-rate herbicides on stormflows are minor because soil infiltration capacity is generally maintained (Lloyd-Reilley, Scifres, and Blackburn 1984). Selective application does not increase stormflows because plant water use is little affected. Broadcast application may produce small increases by reducing plant water use, with typical increases in average stormflow volumes and peaks of about 40 percent for 1 year in small (1-3 acre) watersheds (Neary, Bush, and Grant 1986).

Sediment Loads

Sediment is produced by surface and channel erosion. Surface erosion is minimal in undisturbed forests and is caused by soil exposure and tillage. Channel erosion occurs even in undisturbed forests and increases with peak flows.

Potential surface erosion is shown in Table IV-11. Only a fraction of surface erosion becomes sediment. This fraction (sediment delivery ratio) increases with steeper slopes and denser drainage networks and is reduced by buffers along streams. Because perennial and intermittent streams are protected by buffers, eroded soil is delivered almost solely to ephemeral streams.

Data on average slope steepness and drainage density were used to derive sediment delivery ratios (appendix B) and sediment yields from surface erosion for the various landtypes (Table IV-15). Selective herbicide treatments expose no soil and cause no surface erosion. Broadcast treatments expose little soil and cause minor surface erosion (Neary, Bush, and Grant 1986).

Data isolating channel-eroded sediment from surface-eroded sediment are scarce. Channel sediment increases with peak flow. Increases from broadcast herbicide application should be proportional to increases in average peak flow, typically 40 percent for 1 year (Neary, Bush, and Grant 1986).

2. Effects of Mechanical Methods

Mechanical methods may increase stream nutrients, stormflows, and sediment loads. In general, amount of increase depends on degree of disturbance, topography, and soil type.

Stream Nutrients

Mechanical methods may increase stream concentrations of some nutrients. Drinking water standards are not exceeded

Table IV-15.--Sediment delivery ratios and sediment yields from surface erosion (tons per acre) for treatments by landtype

Landtype	Sediment Delivery Ratio	Mod. Burns Herbicides	Chop/ Shear Pile	Rake Severe Burns	Disk*
OUACHITA PROVINCE					
Arkansas Valley	.06	.036	.055	.272	.584
Ouachita Mountains	.07	.059	.088	.441	.594
OZARK PLATEAUS PROVINCE					
Springfield Plateau	.07	.056	.084	.420	.566
Boston Mountains	.07	.063	.094	.472	.636
COASTAL PLAIN PROVINCE					
St. Francis Unit	.07	.071	.107	.535	.721
Tiak Unit	.01	.000	.001	.002	.009

*Sediment from disking would be greater on all but the Tiak unit if mitigation measures did not require contour disking limited to average slopes of 10 percent.

if mitigation measures (section II.E.2.b) are employed (Fox, Burger, and Kreh 1986; Hewlett 1979; Hollis, Fisher, and Pritchett 1978; Riekerk 1985). Many aquatic systems are nutrient poor, so small increases in nutrients often increase their productivity.

Stormflows

Mechanical methods can increase stormflow volumes and peaks in small watersheds. Mowing causes no increases because it exposes little soil and does not reduce water use by plants. Scarifying causes no increases because it disturbs little soil and increases surface water storage. Contour ripping may decrease stormflow volumes and peaks by increasing surface storage and infiltration and by altering subsurface flow patterns (Miller, Beasley, and Lawson 1985).

Chopping, shearing, and piling retain soil infiltration capacity and cause small stormflow increases by reducing water use by plants. Raking and disking cause larger increases by reducing infiltration and promoting surface runoff. Large increases may affect aquatic biota by eroding and baring streambanks and by scouring and silting streambeds.

In small (1-15 acre), full-treated watersheds, typical increases in average stormflow volumes and peaks are 40 percent for 1 year for chopping, shearing, and piling, and 200 percent for raking and disking with return to pre-treatment levels taking 3 years or more (Beasley and Granillo 1985a; Blackburn, Wood, and DeHaven 1986; Blackburn and others, 1987; Douglass, Van Lear, and Valverde 1983; Miller, Beasley, and Lawson 1988a; Swindel, Lassiter, and Riekerk 1983a, 1983b; Ursic 1986; Van Lear and Douglass 1982). However, Miller, Beasley, and Lawson (1985) found that chopping caused increases below typical levels in some of their watersheds in one Ouachita Mountains study.

Sediment Loads

Mechanical methods can increase sediment loads from both surface and channel erosion in small watersheds. Amount of increase is related to degree of disturbance (Beasley 1979; Beasley and Granillo 1985a, 1985b; Beasley, Granillo, and Zillmer 1986; Blackburn, Wood, and DeHaven 1986; Blackburn and others 1987; Douglass and Goodwin 1980; Ursic 1986).

Sediment delivery ratios were applied to erosion rates to derive sediment yield from surface erosion for the various landtypes (Table IV-15). Mowing, scarifying, and ripping cause negligible surface erosion; mowing exposes little soil, and scarifying and ripping trap soil onsite (Miller, Beasley, and Lawson 1985). Chopping, shearing and piling expose some soil and cause minor surface erosion. Disking exposes and tills the most soil and causes the most erosion.

Channel sediment tends to increase in proportion to average peak flow (Blackburn, Wood, and DeHaven 1986; Blackburn and others 1987), with typical first-year increases is small (1-15) acre) watersheds of about 40 percent for chopping, shearing, and piling, and 200 percent for raking and disking. Larger increases occur from any mechanical method if stream channels are not protected from disturbance by equipment (Miller, Beasley, and Lawson 1988b).

Large sediment increases may block sunlight, impair photosynthesis by algae and aquatic plants, and erode gill filaments of fish and aquatic invertebrates. Once deposited, the sediment can bury aquatic plants and insects, be imbedded in spawning gravels to smother eggs and prevent fry emergence, and fill in deep pools that are vital for fish cover. Sediment increases are minor where raking and disking are not used and mitigation measures (page II-52) are used that limit soil exposure, contour soil disturbances, and employ filter strips along streams.

3. Effects of Prescribed Fire

Prescribed fire may increase stream nutrients, stormflows, and sediment loads. In general, amount of increase depends on fire severity.

Stream Nutrients

Slash burns may produce minor increases in concentrations of some nitrogen compounds and cations, but drinking water standards are not exceeded even by severe burns. Underburns and grassland burns have negligible effect (appendix B).

Stormflows

Moderate slash burns may increase average stormflow volumes and peaks by about 40 percent for 1 year by reducing water use by remaining vegetation. Severe burns cause greater, more prolonged increases by exposing mineral soil and promoting surface runoff (appendix B).

Underburns and grassland burns are light to moderate. Underburns do not affect water use, and grassland burns only affect it for a few weeks until grass regrows. These burns do not affect stormflows (appendix B).

Sediment Loads

Sediment delivery ratios were applied to erosion rates to derive sediment yield from surface erosion for the various landtypes (Table IV-15). Moderate slash burns expose little soil and cause minor surface erosion, but severe slash burns expose much soil and cause substantial erosion (appendix B). Channel sediment increases in proportion to average peak flow (Ursic 1970), with first-year increases estimated to be about 40 percent for moderate slash burns and 200 percent for severe slash burns. Sediment increases are minor where severe slash burns are not used and filter strips (page II-48) are employed along streams.

4. Effects of Biological Methods

Grazing minimally increases stream concentrations of nutrients. Livestock with access to streams increase harmful bacteria in the water, which may remain elevated for months after livestock removal if animal wastes are dropped in or next to the channel. When livestock are prevented from concentrating near streams, animal wastes are processed by litter, duff, and soil and counts of aquatic bacteria rarely exceed water quality standards (Patric and Helvey 1986; Tiedemann and others 1987). Mitigation measures (page II-59) require livestock to be managed to prevent water contamination and streambank damage, so risk to public health is generally low.

Light to moderate grazing commonly reduces soil infiltration capacity by less than 50 percent. Heavy grazing reduces it by 50-90 percent (Blackburn 1984; Patric and Helvey 1986; Wood and others 1987). In Oklahoma and Texas grasslands, 20-30 years of continuous overgrazing increased runoff by more than 100 percent and sediment yield by 10-26 times above moderate rotation grazing (Blackburn 1984).

Heavy grazing increases stormflows by reducing soil infiltration capacity and plant water use. The heavy grazing required for pine release may produce sediment yield from surface erosion ranging up to 3 tons per acre. Channel sediment increases in proportion to average peak flow, estimated to be about 200 percent declining over 3 years.

5. Effects of Manual Methods

Manual methods do not increase stormflow volumes and peaks substantially because plant water use is little affected. Stream nutrients and sediment loads are not increased because litter and duff are left intact and revegetation is not suppressed.

6. Watershed Analysis

Cumulative effects on water include the combined effects of vegetation management and timber harvest onsite, plus those of all other management on all other lands in a watershed. All these effects must be integrated and compared with tolerance limits for the watershed. Cumulative effects analyzed are increased herbicide concentrations, stormflows, and sediment loads.

Cumulative effects were analyzed on typical watersheds in the Interior Highlands. Two large (25,000+ acre) watersheds were used to assess cumulative effects heavily influenced by private management. Four small (3,500-8,000 acre) watersheds that represent each major landtype were used to assess cumulative effects dominated by Forest Service management (Table IV-16).

Table IV-16.--Land use data for typical watersheds, cumulative water effects

Watershed	Landtype	National Forest	Total Acres	N.F. Acres	-----Private Acres-----		
					No Mgt	Timber	Pasture
BROCK CREEK	OZARK PLATEAUS	Ozark	27,990	22,640	2,600	2,610	140
Upper Brock Ck	Boston Mtns.	Ozark	7,820	7,320	360	130	10
Goose Ck	Springfield Plateau	Ozark	3,530	2,930	410	--	190
S FK OUACHITA R	OUACHITA	Ouachita	28,780	20,960	1,830	1,570	4,420
N Fk Ouachita R	Ouachita Mtns	Ouachita	4,570	4,240	--	--	330
Little Bigger Ck	Arkansas Valley	Ozark	4,070	3,980	50	--	40

The St. Francis and Tiak units are in the Coastal Plain, not the Interior Highlands. Representative cumulative effects are analyzed for the loess uplands (St. Francis) and rolling uplands (Tiak) landtypes in the Final EIS for vegetation management in the Coastal Plain/Piedmont (USDA Forest Service 1989).

Cumulative effects are most rigorously analyzed on the four small watersheds. Forest Service land makes up most of their area and downstream mixing and dilution are limited. They were chosen to represent differences in topography, earth materials, and runoff-erosion response to management. Figure IV-4 shows the landtypes in the Interior Highlands and throughout the South.

Herbicide Concentrations

Herbicides used on national forests are applied at low rates, separated from perennial and intermittent streams by buffers, and subject to considerable downstream mixing and dilution. In the maximum herbicide alternative (H), assuming all eligible acres are treated in the same year, less than 8 percent of the watershed is herbicide-treated on national forest land in every watershed. Maximum herbicide concentrations due to national forest use at the mouth of the watersheds should never exceed 0.020 ppm unless herbicides are accidently applied directly to surface water.

Herbicides used on cropland are usually applied every year, at higher rates, and along streams with narrow or no buffers. Peak concentrations measured in runoff range from 1.800 to 5.200 ppm (Wauchope 1978). Considered alone or in addition to other management, risk to water quality from typical application on Forest Service land is minimal.

Stormflows

Timber harvest increases average stormflow volumes and peaks in proportion to percent of stems cut. Increases from clearcut 1-16 acre watersheds average 40 percent for 1 year (Douglass, Van Lear, and Valverde 1983; Settergren and Krstansky 1987; Ursic 1970). Additional first year increases in 1-15 acre watersheds are: 40 percent for broadcast herbicides, chopping, shearing, piling, and moderate slash burns; and 200 percent for raking, disking, severe slash burns, and heavy grazing.
Stormflow peaks are subject to considerable flattening downstream from turbulence and dilution. Increases from clearcut 74-108 acre watersheds average only 5-10 percent for one year (Hewlett and Helvey 1970; Patric 1980; Reinhart, Eschner, and Trimble 1963). Unchanged flows coming from undisturbed portions of a watershed further moderate increases from disturbed portions. In the maximum treatment alternative (H), average stormflow increases at the mouth of the watersheds due to national forest management are 1-5 percent. Adding the effects of private land management, average stormflow increases range from 2 to 7 percent.

This analysis inflates estimated stormflow increases because it assumes that maximum rates of timber harvest are used, all eligible acres are treated in the same year, and stormflows from national forest and private lands are synchronized. Such conditions are rare in actual practice. In addition, these increases represent average-sized stormflows. Increases during large floods, which cause nearly all flood damage and occur when soils over the entire watershed are saturated, would be much less and negligible in all watersheds.

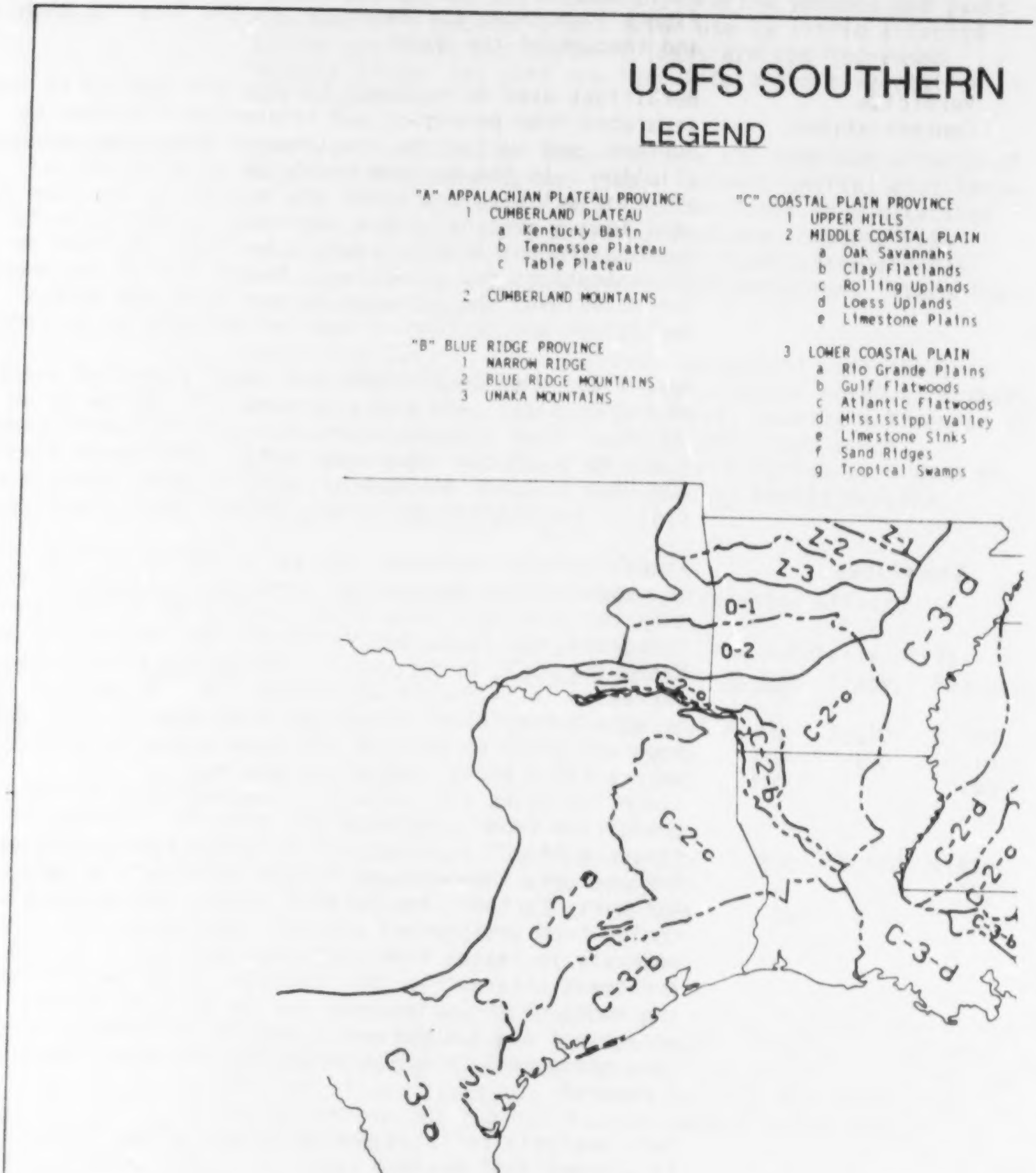

USFS SOUTHERN
LEGEND
"A" APPALACHIAN PLATEAU PROVINCE
1 CUMBERLAND PLATEAU
a Kentucky Basin
b Tennessee Plateau
c Table Plateau
2 CUMBERLAND MOUNTAINS
"B" BLUE RIDGE PROVINCE
1 NARROW RIDGE
2 BLUE RIDGE MOUNTAINS
3 UNAKA MOUNTAINS
"C" COASTAL PLAIN PROVINCE
1 UPPER HILLS
2 MIDDLE COASTAL PLAIN
a Oak Savannahs
b Clay Flatlands
c Rolling Uplands
d Loess Uplands
e Limestone Plains
3 LOWER COASTAL PLAIN
a Rio Grande Plains
b Gulf Flatwoods
c Atlantic Flatwoods
d Mississippi Valley
e Limestone Sinks
f Sand Ridges
g Tropical Swamps
Z-2
Z-1
Z-3
O-1
O-2
C-3-d
C-2-a
C-2-a
C-2-b
C-2-c
C-2-d
C-2-a
C-2-a
C-3-b
C-3-d
C-3-b
C-3-a

Figure IV-4.--Landtypes of the Ozark/Ouachita Mountains

REGION LANDTYPES

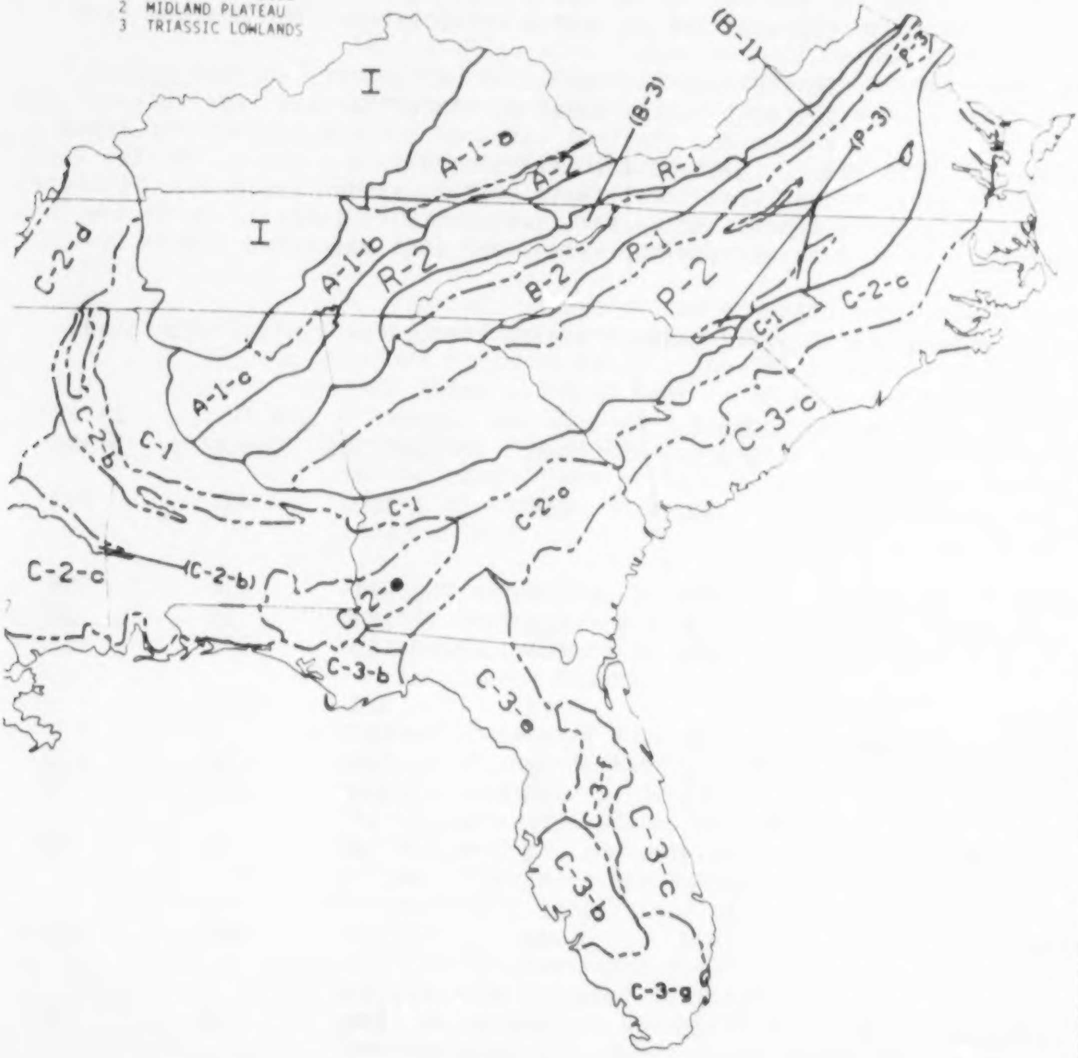
"I" INTERIOR LOW PLATEAUS PROVINCE

"O" OUACHITA PROVINCE
- 1 ARKANSAS VALLEY
- 2 OUACHITA MOUNTAINS

"R" RIDGE AND VALLEY PROVINCE
- 1 FOLDED HIGHLANDS
- 2 FAULTED LOWLANDS

"Z" OZARK PLATEAUS PROVINCE
- 1 SALEM PLATEAU
- 2 SPRINGFIELD PLATEAU
- 3 BOSTON MOUNTAINS

"P" PIEDMONT PROVINCE
- 1 UPLAND FOOTHILLS
- 2 MIDLAND PLATEAU
- 3 TRIASSIC LOWLANDS


I
(B-1)
P-3
A-1-a
A-2
(B-3)
R-1
(P-3)
I
C-2-d
A-1-b
R-2
B-2
P-1
P-2
C-2-c
C-1
A-1-c
C-3-c
C-2-b
C-1
C-1
C-2-a
C-2-c
(C-2-b)
C-2-a
C-3-b
C-3-a
C-3-f
C-3-b
C-3-c
C-3-g

Sediment Loads

Channel erosion occurs even in undisturbed forests. Typical annual sediment yield from channel erosion in undisturbed small watersheds in good hydrologic condition is 20 lb/ac in the Ozark and Ouachita Mountains (Miller 1984; Miller, Beasley, and Lawson 1988b, 1985; Rogerson 1971, 1976, 1985; Ursic 1986).

Channel erosion increases in proportion to average peak flow. In this analysis, clearcuts are estimated to increase channel sediment an average of 40 percent for 1 year. Additional increases are estimated to be: 40 percent for broadcast herbicides, chopping, shearing, piling, and moderate slash burns; and 200 percent for disking, severe slash burns, and heavy grazing. Increases in channel sediment are estimated at 40 percent for pasture land.

In addition to vegetation management, surface-eroded sediment is increased by timber harvest, agricultural use, and roads. Typical rates of surface erosion for these uses were combined with sediment delivery ratios for the various landtypes to estimate surface-eroded sediment. Estimates of channel and surface sediment were combined to derive total 10-year sediment yield for each watershed (Table IV-17).

Table IV-17.--Cumulative 10-year sediment yields (tons) for typical watersheds

	BROCK	Upper Brock	Goose	S FK OUACHITA	N Fk Ouachita	Little Bigger
NATURAL	2,800	782	353	2,880	457	407
FS: Roads	3,727	890	378	2,871	314	158
Harvest	148	36	23	284	58	34
	3,875	926	401	3,155	372	192
PVT: Roads	651	-	21	1,428	210	-
Forest	444	23	-	251	-	-
Pasture	33	2	38	1,154	86	10
	1,128	25	59	2,833	296	10
VEG MGT (ALT. H)	91	23	6	58	15	26
TOTAL INCREASE	5,094	974	466	6,046	683	228
PERCENT INCREASE	182	125	132	210	149	56

High rates of timber harvest and alternative H were modeled to show a maximum effect. Channel erosion was computed by multiplying acres treated by the proper increase rate for each practice. **Surface-eroded sediment** was computed as follows:

1. For roads, acres of road were multiplied by typical erosion rates for dirt and gravel roads. Existing roads are permanent and erode every year. New timber access roads are open temporarily and erode for only 1 year.

2. For timber harvest and pasture, acres treated were multiplied by USLE factors for each watershed. Cover factors (USFS and private) are 0.002 and 0.005 for timber harvest and 0.003 for pasture (Dissmeyer and Stump 1978). Skid trails, with higher erosion rates, cover 5 and 10 percent of timber harvest. Pasture erodes every year but timber harvest normally erodes for only 1 year.

3. For vegetation management (alternative H), acres treated were multiplied by erosion values in table IV-13. On private forest land, erosion from site preparation was added to that from private timber harvest in the "forest" category.

4. In each category, the computed erosion was multiplied by a sediment delivery ratio (SDR) to derive the sediment values in table IV-17. The SDR assumes a sediment source zone whose width in feet is 50 plus 3.0 times percent slope for roads and 40 plus 1.4 times percent slope for areal treatments (Swift 1986). Filter strips occur along perennial and intermittent streams on national forests, perennial streams only on private forest land, and seldom on pasture land.

For each watershed, table IV-17 shows natural sediment yield and the contribution of each management category. The total man-caused sediment is shown and expressed as a percent increase above natural sediment.

A chief concern of increased sediment is its effect on quality of aquatic habitat. Risk to habitat quality is rated as minimal for increases of 0-100 percent, low for 100-200 percent, medium for 200-300 percent, high for 300-400 percent, and extreme for increases greater than 400 percent (Alexander and Hansen 1986; Heller, Maxwell, and Parsons 1983; Stowell and others 1983).

Table IV-17 shows that for 5 watersheds, risk to aquatic habitat from sediment is minimal to low. Increases are small on watersheds with little private land and relatively low road density. Most of the increased sediment comes from the existing network of open roads which erodes chronically year after year.

The data indicate a medium sediment risk in the South Fork Ouachita River. In these large watershed, almost 90 percent of the increased sediment is caused by private pasture land and high road densities (over 2 miles per square mile) affecting streams with low natural sediment yields.

In every watershed except Little Bigger Creek, vegetation management (alternative H) accounts for 0-2 percent of the total increased sediment. In no watershed does vegetation management worsen the sediment risk to aquatic habitat or biota.

The risk classes for habitat quality used here are based on studies in the Great Lakes, Pacific Northwest, and Rocky Mountains areas, so they should be used with caution in the absence of local data. The Ouachita National Forest is now doing an aquatic habitat inventory which may be used to refine our estimates of risk.

7. Data Gaps

Data are lacking that isolate effects of vegetation management on channel sediment in the South. Effects on stormflows have been studied, but channel sediment has seldom been isolated from surface-eroded sediment. Channel sediment makes up a significant share of total sediment load, so data on how management affects it are important. The Council on Environmental Quality mandates a process for evaluating incomplete and unavailable information (40 CFR 1502.22).

To provide complete information, timber harvest and vegetation management activities must be studied on an array of landtypes in the South. Studies must be strictly controlled to isolate channel sediment due to increased stormflows from sediment due to surface erosion. Such a research program would be very difficult to implement, cost several hundred thousand dollars, and require 10 years or more. The Forest Service views these costs as too high to justify delay of this EIS.

CEQ regulations require that existing credible evidence be summarized and impacts be evaluated using accepted methods. Existing studies where surface erosion was essentially absent suggest that channel sediment typically increases roughly in proportion to peak flow. The processes involved are well understood but complex, so we have expressed percent increase in channel sediment as equal to percent increase in peak flow for ease of explanation. For example, chopping increases peak flow an average of 40 percent and so is estimated to increase channel sediment by 40 percent.

H. AIR QUALITY

Air is a dynamic resource whose quality fluctuates over time and space. Key air quality concerns are concentrations of gases and particulates that may impair human health and welfare. Prescribed fire is the only vegetation management method that emits substantial amounts of gases and particulates to the atmosphere. Prescribed fire presently occurs on about 2 percent of national forest land in the Ozark/Ouachita Mountains each year. On a given site, slash burns may occur once every 40-120 years and underburns every 3-7 years. Effects on air quality are brief and intermittent in each area affected.

Periodic fires have heavily influenced forests of the Interior Highlands. Shortleaf and loblolly pine are fire-dependent subclimax species that are naturally succeeded by hardwoods in the absence of fire. These pines and many upland hardwoods (especially oaks) have adapted to periodic burning regimes (Johnson and Schnell 1985a, 1985b). The air quality of the area has thus been subject to the influence of wildland fires for thousands of years.

Wildfires emit the same pollutants as prescribed fires. In general, emissions from wildfires are greater per acre burned and often occur at times when winds may carry smoke directly into sensitive areas. Smoke dispersion is also impaired when wildfires burn into the night (Sandberg and Ward 1981).

Any wildland fire burns in 4 phases (McMahon 1983; National Wildfire Coordinating Group 1985; Sandberg and others 1979). During preignition, fuels ahead of the fire are heated and dried and gases are released. During flaming combustion, temperatures rise rapidly, gases are flamed, and black smoke dominated by solid soot particles is produced. During smoldering combustion, temperatures drop and gases condense to produce white smoke composed mostly of liquid tar droplets. Smoldering emits 2-5 times the particulates as flaming. During glowing combustion, all combustible gases have been driven off, no visible smoke is produced, and carbon monoxide and carbon dioxide are the chief emissions.

1. Gases

EPA considers some gases emitted by prescribed fire (carbon monoxide, hydrocarbons, nitrogen and sulfur oxides, and photochemical oxidants) to be pollutants (McMahon 1981). Emission of these gases by prescribed fire, summarized by McMahon (1983), National Wildfire Coordinating Group (1985), Sandberg and Ward (1981), Sandberg and others (1979), USDA Forest Service (1976), and Van Lear and Johnson (1983), is discussed below. Additional health risk to workers and the public from burning herbicide-treated (vs. non-treated) vegetation is negligible (McMahon 1989).

Carbon Monoxide

This colorless, odorless, toxic gas is the most abundant air pollutant from forest fires. Its adverse effect on human health depends on exposure time, level of physical exertion, and concentration of gas. Typical emission factors range from 40 lb per ton of fuel consumed during flaming, to 200 lb/ton during smoldering, to 500 lb/ton in smoldering slash piles and organic soil. Concentrations may be 100-200 ppm at the fireline but diluted to less than 10 ppm about 100 feet downwind, so public health hazards are negligible.

Hydrocarbons

Hydrocarbons contain hydrogen, carbon, and sometimes oxygen. Typical emission factors are 30-100 lb/ton of fuel consumed, with most produced during smoldering. Most hydrocarbons have no harmful effect, but several, called polycyclic organic matter (POM), are carcinogens. These substances are produced by burning any carbon-based fuel. Forest fires account for only 3 percent of the national POM total (Anonymous 1984). Risk of developing cancer due to POM from prescribed fire is estimated to be less than 1 in a million (Dost 1986).

Nitrogen Oxides

At high concentrations, these toxic gases can affect the lungs. Prescribed fires emit only minor amounts by oxidation of fuel nitrogen. Most forest fuels contain less than 1 percent nitrogen, of which 20 percent is converted to nitrogen oxides when burned. Concentrations are not high enough to affect human health.

Sulfur Oxides

Emissions of sulfur oxides are negligible because most forest fuels contain less than 0.2 percent sulfur. Emission factors for woody fuels are less than 0.4 lb/ton. Risk of adverse effects on human health is minimal.

Photochemical Oxidants

Ozone can form in the upper layer of smoke plumes exposed to sunlight. Concentrations of up to 0.1 ppm have been reached in some plumes, usually in the first hour and within 2 miles downwind. Formation of photochemical oxidants by prescribed fire is a minor problem due to its intermittent occurrence.

2. Particulate Matter

Particulate matter, a complex mixture of solid and liquid particles, makes up the visible smoke seen in all fires. Particles 0.3-0.8 micron in diameter absorb and scatter light most efficiently. Those less than 10 microns in diameter can be inhaled. Those less than 2.5 microns in diameter can be breathed into the lungs. The average particle diameter in forest fire smoke is 0.1-0.3 micron; 90 percent of particles are less than 2.5 microns and nearly all are less than 5 microns (McMahon 1983; Sandberg and Ward 1981; Sandberg and others 1979; Van Lear and Johnson 1983).

Effects of particulates on air quality are analyzed here in 3 phases. Local effects are those felt near the burn. General effects are those felt over an area downwind from the burn. Regional effects are the cumulative effects of particulate emissions over the whole Interior Highlands.

Air Quality Standards

EPA has developed air quality standards for particulates to protect public health from respiratory damage and public welfare from impaired visibility and transportation hazards. The new PM_{10} standard applies to particulates less than 10 microns in diameter. It is exceeded if PM_{10} concentrations exceed an average of 150 micrograms per cubic meter (ug/m^3) for more than one 24-hour period per year, or an average of 50 ug/m^3 for an entire year (Stonefield 1987).

In addition to these general air quality standards, the Clean Air Act mandates special protection for visibility in Class I areas. There are two Class I areas in the Interior Highlands (section III.B.6). The basic strategy is to limit the total effect from all sources to less than a specified increase above a chosen baseline concentration. EPA may soon develop a $PM_{2.5}$ standard, for particulates less than 2.5 microns in diameter, which may have more impact on preserving visibility in Class I areas (Stonefield 1987).

In general, the states have responsibility for monitoring and enforcing air quality standards. National forests must comply with state regulations as well as our own smoke management guidelines.

Local Effects

In the South, the major effects of smoke on air quality are visibility reduction and respiratory impairment near the fire, especially on highways, at airports, and in populated areas. Particulate concentrations may meet the 24-hour standard of 150 ug/m^3 but exceed it by 10-fold or more for short periods. Personal exposure to such effects should occur only once every few years at most. This phenomenon is widely recognized, and research efforts have been organized to help control any temporary problems it might cause.

During flaming, smoke rises in a smoke plume. During smoldering, heat release is not enough to sustain plume rise so smoke stays near the ground. Ground smoke may worsen during inversions or in stable night air when rising humidity can cause a smoke-fog mixture to form. This problem can be especially acute in river valleys. Use of smoke management guidelines mitigates impacts by enhancing flaming, reducing smoldering, and burning during atmospheric conditions that favor smoke dispersion (Lavdas 1986; McMahon 1983; National Wildfire Coordinating Group 1985; Paul, Lavdas, and Wells 1987; Petersen and Lavdas 1986).

Flaming is enhanced by using backing and flanking fires, which move slowly enough to preheat fuels and create a more uniform flame zone to consume gases. Smoldering is reduced by burning when large fuels are moist and unavailable and small fuels are dry, by broadcast burning slash rather than in piles (or at least keeping soil out of piles), and by promptly mopping up after the burn (McMahon 1983; National Wildfire Coordinating Group 1985; Pyne 1984; Sandberg and Ward 1981).

A slightly unstable atmosphere favors smoke dispersion. Such conditions are often characterized by good visibility, cumulus clouds, clear days, steady winds, and low to moderate humidity. Burning during downslope winds or high humidities should generally be avoided (National Wildfire Coordinating Group 1985; Paul, Lavdas, and Wells 1987).

General Effects

Smoke can impair general air quality in sensitive areas downwind from extensive burning. Use of smoke management guidelines mitigates impacts by reducing smoke emissions and burning during atmospheric conditions that favor smoke dispersion (Lavdas 1986; Petersen and Lavdas 1986; Sandberg 1983; USDA Forest Service 1976). Following is a discussion of smoke emission and dispersion principles.

SMOKE EMISSIONS are a product of emission factor (pounds of particulates produced per ton of fuel consumed) and amount of fuel consumed. Emissions are reduced by increasing combustion efficiency, which is highest during flaming and when small fuels are homogeneous, loose, and dry. Backing and flanking fires produce one-third of the smoke that head fires do. Mass-igniting slash burns, which reduces buildup time to flaming, can reduce emissions of a fire under ideal conditions by up to 25 percent. Broadcast burning slash rather than in piles (or at least keeping soil out of piles) greatly reduces smoldering (Sandberg 1983; Sandberg and Ward 1981; Sandberg and others 1979).

Emissions are also reduced by limiting fuel consumption. Slash burning when duff and large fuels are moist and unavailable limits smoldering and can reduce emissions of a fire under ideal conditions by up to 50 percent. This strategy is accomplished by scheduling slash burns soon after a soaking (0.5 inch or more) rain. Emissions from smoldering are also reduced by promptly mopping up after a burn (National Wildfire Coordinating Group 1985; Sandberg 1983, 1985; Sandberg and Ward 1981).

ATMOSPHERIC DISPERSION can lessen general effects through two smoke management strategies. "Avoidance" uses wind direction to send smoke away from sensitive areas. "Dilution" uses favorable weather conditions to reduce concentrations of smoke in sensitive areas downwind (Sandberg 1983)

Avoidance is most appropriate for reducing impacts to nearby areas by sending smoke away from them. To be successful, variations in wind direction over time and space must be considered. Because predicting wind direction is difficult for more than 24 hours, during light winds, and at night, avoidance is not usually appropriate for long-duration fires or fires that smolder into the evening.

Dilution relies on mixing smoke with clean air vertically and horizontally. Atmospheric stability, mixing height, and transport windspeed govern this process (National Wildfire Coordinating Group 1985; Pyne 1984; USDA Forest Service 1976).

Atmospheric stability affects rate of smoke dispersion. An unstable atmosphere is turbulent and rapidly mixes smoke. Slight instability usually provides adequate smoke dispersion but maintains a steady enough wind for good fire control. A neutral atmosphere may provide adequate dispersion, depending on other atmospheric factors.

Mixing height also affects rate of smoke dispersion. It is the vertical extent of unstable air, capped by an inversion or windshear layer, that allows vertical spread of a smoke plume through convection and turbulence. High mixing heights mean large volumes of air may be available for smoke dispersion. To provide adequate dispersion, mixing heights should exceed 1,650 feet. Lower mixing heights are most common under low inversions and windshear layers, under stagnant high pressure systems, and on the cold air side of warm, stationary, or weak cold fronts. On generally clear nights with light winds when surface temperature inversions form, there is no mixing height and smoke is trapped near the ground and spreads very slowly.

Transport windspeed is the average windspeed in the layer of air likely to contain smoke. Adequate smoke dispersion requires a transport windspeed of at least 9 mph.

Combinations of atmospheric stability, mixing height, and transport windspeed needed for good smoke dispersion are most common between high and low pressure systems and behind vigorous cold fronts. The combined effects of atmospheric stability, mixing height, and transport windspeed on smoke dispersion have been expressed in a numerical rating called the "dispersion index" (Lavdas 1986).

Regional Effects

Regional effects on air quality are analyzed as the cumulative smoke emissions of all prescribed fires and wildfires on all lands in the Interior Highlands. Prescribed fire accounts for 17 percent of emissions from wildland fires in the South (Sandberg and others 1979). Even in alternative H, prescribed fires on national forests total 71,900 acres per year, only 6 percent of all prescribed fire acres in the area. National forest prescribed fires should thus account for only 1 percent of smoke emissions from wildland fires (0.17 x 0.06) and have negligible effects on regional air quality.

Other regional and global concerns are acid deposition, the greenhouse effect, and ozone impacts. Prescribed fires emit relatively minor amounts of organic acids and nitrogen and sulfur oxides to the atmosphere, so their impact on acid deposition is negligible. They also release calcium and magnesium to air and soil, so they may actually reduce acid deposition locally (appendix B).

The greenhouse effect depends on the balance between global outputs of oxygen and carbon dioxide. The ozone layer is affected by global outputs of ozone-depleting compounds that reach the upper atmosphere. Wildland fires emit large amounts of carbon dioxide and smaller amounts of other "greenhouse" gases. They also emit compounds that can act as precursors for both ozone production and depletion. But forestry prescribed fires emit tiny amounts of such gases compared to other forms of biomass burning. All prescribed fires in all temperate forests of the world are estimated to account for only 0.1-0.4 percent of the global biomass burned annually (Seiler and Crutzen 1980).

3. Emission Estimates

Effects of the alternatives on air quality are analyzed by estimating total smoke emissions from prescribed fires and wildfires on national forests. Emissions are a product of emission factors, fuel loads, and acres burned in each of two major fuel groups:

a. **Grass**--pastures and cedar glades.

b. **Light brush**--pine and hardwood-pine fuel types (including hardwood type when prescribe burned).

Emission factors vary by fuel consumed and combustion mode. Available fuels include grass in grass burns, plus litter and brush in underburns, plus tree limbs and foliage in slash burns and wildfires. Smoldering increases emission factors, which are typically 15 lb/ton for grass burns, 75 lb/ton for light brush underburns and slash burns, and 100 lb/ton for forest wildfires (McMahon 1983; Sandberg 1983; USDA Forest Service 1976; Ward 1983).

Available fuel load depends on fuel type, buildup, arrangement, and moisture content. Typical available fuel loads for underburns are 3-4 tons/ac in grass and light brush fuels (Mutz and others 1985; Sackett 1975; USDA Forest Service 1976). Wildfires in underburned stands consume 1 ton more than underburns because they tend to burn under drier conditions. If underburns are excluded, available fuel for wildfires can eventually build up to 8-10 tons/ac in light brush fuels (USDA Forest Service 1976).

Underburns interrupt fuel buildups, slowing the spread and aiding the control of wildfires. Excluding underburns in heavy brush fuels may increase average acres burned by wildfire by up to 100-fold (Davis and Cooper 1963). In the Interior Highlands, however, heavy brush fuels are absent. Excluding underburns should increase wildfire acres only in large tracts of light brush fuels under pine or pine-hardwood overstories; increases are estimated to be a conservative 5-fold. Such tracts occur mostly in the Arkansas Valley, Ouachita Mountains, and Tiak unit.

In each alternative, the acres burned by prescribed fire and wildfire are multiplied by the emission factors and fuel loads discussed above to estimate total smoke emissions from each fuel group. Slash burns occur mostly in pine and pine-hardwood stands and underburns mostly in light brush fuels under pine and pine-hardwood overstories. Grass burns occur in pastures and cedar glades. See section IV.M (Summary of Impacts by Alternatives) for smoke emission estimates.

I. WILDFIRE

Periodic fires have heavily influenced Ozark/Ouachita forests. Most pines are fire-dependent and many hardwoods are adapted to fire. Prescribed fire can affect the occurrence and spread of wildfires.

1. Escaped Prescribed Fires

Prescribed fires can become wildfires when they accidentally escape their boundaries and burn adjacent areas. These effects are mitigated by burning under fuel and weather conditions that promote control of fire spread. In general, escaped prescribed fires are quickly controlled, so their effects are minimal.

2. Fuel Reduction

Underburns slow the spread and aid the control of wildfires by interrupting fuel buildup beneath pine and pine-hardwood overstories. When underburns are excluded in such fuel types, fire hazard increases progressively as litter accumulates, flammable understory shrubs increase in size, and needle drape develops, providing a pathway for surface fire to reach tree crowns (Wade 1983).

Unless reduced by underburns, fuels build up beneath pine stands until an equilibrium is reached between accumulation and decomposition (Wade 1983). Litter fuels reach equilibrium in 5-10 years (Sackett 1975), but time to total fuel equilibrium may take several decades (Wade 1983).

Available fuels in underburned stands amount to 3-6 tons per acre (USDA Forest Service 1976). If underburns are excluded, available fuels for wildfires can build to 8-10 tons per acre in grass and light brush fuels (Martin and others 1979; USDA Forest Service 1976).

Underburns done in cycles longer than 7 years can damage the overstory and can be harder to control. Excluding underburns in large tracts of light brush fuels under pine or pine-hardwood overstories may increase average acres burned by wildfire by 5-fold. Over time, increased recreation use of national forests should increase risk of wildfire occurrence.

Prescribed fires also decrease wildfire hazard on adjacent lands. Excluding underburns increases spread of wildfire from national forests to these lands. Over time, increased urbanization should increase wildfire hazard to people and property.

J. VISUAL QUALITY

Introduction

Of all landscape elements, vegetation is the most significant visual feature and is the element most readily manipulated. Manipulation intensity and timing affect the significance of impact on visual quality. A favorable climate and vegetation variety allow vegetation to recover quickly after most treatments. In assessing effects of treatments in each alternative, it is assumed that management requirements and mitigation measures (chapter II) are employed. Also assumed is that visual quality objectives for treatment areas are met, except for alternatives A and H. Variables that affect scenic quality are treatment type, number of acres treated, slope, and duration of effect, visibility and season of year.

1. Effects of Prescribed Fire

Prescribed fire temporarily reduces understory vegetation and can maintain open forested conditions with more opportunity for views and vistas. Reduction of underbrush creates better pedestrian access. Periodic fire also promotes numerous flowering plants.

Understory burns create a charred appearance on tree trunks, lower limbs, and forest floor that lasts 3 to 4 months. With more intense burns and in hot spots, more of the tree is charred and often tree-crown scorch occurs. Site preparation burns create a charred appearance over broader landscape areas with few vertical breaks, but these effects are diminished quickly as new sprouts turn the area green. The effect can last 3-5 years or more. Smoke accumulations on relatively calm days reduces visibility in downwind areas and in valley bottoms. Windier days disperse smoke faster and keeps visibility higher, but may affect larger areas.

Repeated treatments of fire in the same area can reduce understory species and maintain side spacing between trees. On rights-of-way variety changes from tall trees to shrubs, herbs, and grasses; however, the number of plants increases considerably. The vegetation mix remains dynamic and fluctuates with treatments. These changes favor a variety of wildflowers, flowering shrubs, grasses, and other plants (Bramble and Byrnes 1982).

2. Effects of Mechanical Methods

Mechanical methods can expose soils and generally reduce vegetation to ground level or less than 3 feet high. Considerable seasonal browning occurs and broken stems create an unsightly landscape. Raking and piling leave debris that may be visible 3 to 4 years before being obscured by new growth, unless the windrows or piles are burned. Mechanical treatments also reduce shading vegetation and allow more wildflowers and other sun-tolerant plants to come into the area until trees and shrubs shade or crowd them out.

3. Effects of Manual Methods

Manual treatments leave browned slash and a graying appearance for a season to a year. Regrowth and residual vegetation obscure the effect within a few months. Canopy heights are reduced, but species variety is generally maintained.

4. Effects of Herbicides

Herbicide treatments reduce variety by eliminating target species, but the space is usually filled quickly by lower-growing shrubs, grasses, or herbs. Herbicide treatments also create a browning and then a graying that can last from a season to several years depending on the treated vegetation's height and the herbicide's persistence. For example, stem injection of large stems produces a very long-lasting effect. Frequent treatments such as those on rights-of-way have less lasting visual effects. Broadcast applications create a stronger visual effect than more selective ones. Hand applications generally create irregular or spot patterns of brown and gray. Less total area receives treatment due to the selective application.

5. Effects of Biological

The light to moderate grazing has a negligible effect on visual quality.

K. CULTURAL RESOURCES

Effects on cultural resources are associated with activities that cause soil disturbance, particularly mechanical treatments, but may also be directly associated with prescribed or wildfires.

Effects of mechanical treatments increase as depth of penetration into soil or movement of soil from one place to another increases. For example, mowing and shearing do not penetrate soil, but such tools as ripping and disking do. Effects from fire are generally limited to those resources on or above ground such as buildings.

Vegetation management should not be viewed as a single, isolated activity, but rather as one element of a broader resource management program. Thus, roads, trails, powerlines and pipelines may already have been built and timber may have been harvested. These activities can cause substantial soil disturbance without vegetation management.

Each cultural resource is a piece of a puzzle that tells us about earlier societies. Loss or damage of a single artifact may limit our knowledge and understanding of earlier societies, but this loss may not always be critical. As more artifacts are lost, however, interpretation becomes increasingly difficult. Related to this cumulative loss is the fact that cultural resources are afforded greater protection on Federal lands than on others. Loss or damage of cultural resources on other lands could increase the significance of such resources on Federal lands.

L. SOCIOECONOMIC CONDITIONS

People who live, work, or visit in or near the Ozark, St. Francis, or Ouachita National Forests are affected by vegetation management. Generally, however, these effects are dwarfed by the magnitude of other local, national or even global trends.

1. Effects on People's Expectations

People's expectations cover the range from primitive to rural (chapter III). Vegetation management enhances the ability of forests to meet some expectations and detracts from the ability to meet others. Factors that adversely affect experience quality would generally have more negative impacts on neighbors/newcomers and visitors than on workers/long-term residents. Factors that affect jobs and employment would have more effect on workers/long-term residents. Magnitude of these effects would influence the amount of social conflict that might occur if various alternatives were implemented.

2. Effects on Employment

Despite more substantial influences from regional or national trends, rural communities depend heavily on agriculture/forestry and related services. Employment relates to labor intensity of the practices used (Watson, Straka, and Bullard 1987). Though this study is based on Coastal Plain and Piedmont work activities it is reasonable labor component data for the Ozark/Ouachita Mountains. The total labor component, including supervision and overhead, for each method is:

*Method	Percent Labor
Mechanical	39
Prescribed Fire (Ground)	67
Prescribed Fire (Aerial)	49
Herbicide (Ground)	26
Herbicide (Aerial)	17
Manual	92

*Biological data are not included in this study, but herd management (labor) represents a small component.

3. Effects on Civil Rights

In every alternative, effects on civil rights, including those of minorities and women, will be statistically insignificant and unplanned. Analysis of possible effects occurs in the site-specific environmental analysis or during project design. The following topics are of concern:

- Risks to worker health and safety because racial and cultural minority groups may represent a large fraction of this work force;
- Employment opportunities and representation in the work force for minorities and women.

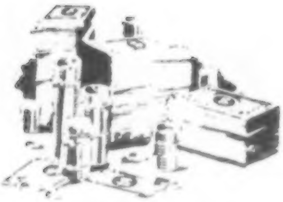
4. Effects on Outputs and Costs

Some outputs are generated at the expense of others, or output levels may change with intensity of treatment. Additionally, costs for conducting vegetation management vary. Some treatments are long-lasting while others must be repeated. Some require little labor or equipment and others require much.

Production of outputs in many cases requires vegetation management. Each multiple use including forage, recreation, water, wildlife, and wood is affected. Conversely, lack of treatment is sometimes essential for these outputs. For example, vegetation management is done to retain or improve vistas for road tours, but little is done in a primitive setting where a closeness to nature is desired. Each is a recreation output and each requires different treatment.

Information on activity cost, acres, method of treatment, and purpose was collected from the Ozark, St. Francis, and Ouachita National Forests for work done during fiscal years 1987 and 1988. These figures represent an expenditure of $5.1 million (labor, materials, handling, equipment, supervision) on 86,000 acres. Average costs by method and tool are shown in table IV-18.

Average costs by activity are:



Activity	Average Cost/Acre		
	Pine	Hardwood	Mixed
Site preparation	$ 56.36	$66.23	$57.09
Stand management	54.71	46.34	53.64
Wildlife			
Habitat Improvement	17.44	56.67	46.99
Openings Maintenance	132.11		132.11
Corridor Maintenance	39.21		39.21
Range forage	16.11		16.11
Fuels treatment	14.82		14.82

Vegetation management may change the amount of money passing through the economy, particularly in the form of wages and 25-percent returns to county governments. It may also change indirect costs and opportunity costs. For instance, action or lack of action at the right time and place results in later costs or loss of subsequent benefits. Local or

Table IV-18.--Vegetation management costs per acre by method, Ozark/Ouachita Mountains

Vegetation Management Method	-----Per Acre Cost-----	Average Cost/ Acre (Not utility ROW)
Herbicide		61.73
Aerial tools		
Helicopter		
Utility ROW	120.00	
Site Preparation	68.41	
Release	55.19	
Mechanical ground tools		
Boom sprayers	76.22	
Granular spreader	71.76	
Utility ROW	160.00	
Hand tools		
Backpack sprayers	38.98	
Spotgun	53.00	
Hypo-hatchet	45.81	
Injectors	53.46	
Hack & Squirt	83.96	
Backpack sprayers/injectors	36.71	
Backpack sprayers/spot gun	92.52	
Utility ROW	480.00	
Manual		55.03
Power tools		
Chainsaws	50.25	
Brushcutters	56.98	
Hand tools		
Axe	56.45	
Brushhook/chainsaw	56.[illegible]	
Utility ROW		
Less than 30% slope	160.00	
More than 30% slope	200.00	
Mechanical		65.75
Chopping tools	54.27	
Ripping tools	59.21	
Disking tools	54.34	
Mowing tools	43.70	
Piling, Raking tools	72.50	
Utility ROW (where slope allows)	160.00	
Chopping/Ripping	106.70	
Scarifying/Pile	69.42	
Prescribed Fire		11.43
Aerial ignition devices	6.76	
Drip, drag torches	16.91	
Biological - No data		
Manual and Herbicide Combinations		51.77
Power tools and Backpack sprayers	65.94	
Power tools and Injectors	101.28	
Handtools and Injectors	55.67	
Handtools (chainsaw and spotgun)	34.17	
Mechanical and Herbicide Combinations		111.89
Scarifying-Velpar-L Application	111.89	

area economics and social structures adjust over the long term to reflect labor force needs, services, and money flowing through the community. Both supply and demand tend to adjust toward equilibrium.

M. SUMMARY OF IMPACTS BY ALTERNATIVES

This section displays overall environmental effects of each alternative. A capsule of the alternative's program is followed by an element-by-element discussion of environmental effects. This section forms the basis for the comparison of alternatives in sections II.B and II.H.

Alternative A

This is the "no action" alternative. Vegetation management is not done. Existing vegetation is allowed to grow without manipulation.

Human Health and Safety

Neither workers nor the public are exposed to vegetation management tools. Indirect health and safety risks increase over time as vegetation encroaches on corridors and builds up fuel loads.

Failure to maintain road rights-of-way creates high risks for human health and safety. Roadside vegetation grows uncontrolled and obstructs vision, making roads hazardous within 3-5 years. Road surfaces are also damaged. Risk of power outage results when vegetation grows in rights-of-way and contacts transmission wires.

Exclusion of prescribed fire permits hazardous fuels to accumulate. Wildfire hazard with associated risk to human health and safety is high. Risks of wildfire-related injury increase over time at different rates based on fuel type, age, and other ecological factors.

Noxious weeds grow unchecked. Forest visitors are exposed to more weeds resulting in a higher proportion of visitors suffering minor health problems than in alternatives where noxious weeds are controlled.

Vegetation

Succession following timber harvest proceeds uninterrupted except for natural occurrences such as wildfires, floods, tornadoes, and ice and snow damage. Complete regeneration failures, as well as marginal survival and loss of growth and form, occur for both natural and planted pine and hardwood species on harvested areas with vigorous competing vegetation. Herbaceous species gradually decline. Shade-tolerant woody species gradually replace shade-intolerant species in the midstory and overstory.

Wildfires occurring during dry weather in accumulations of hazardous fuels are of high intensity, causing significant injury and mortality to vegetation. Greater mortality of woody vegetation occurs during the growing season.

Wildlife

Prescribed fire and other treatments are unavailable for improving habitat for any species. Fire-dependent species such as quail decline. Because intermediate treatments are not done, regeneration areas rapidly lose their value for species like deer as forage and browse production declines.

Increased wildfires create habitat for early successional species but destroy habitat for mid to late successional species such as brown-headed nuthatch (Sitta pusilla) and pileated woodpecker (Hylatomus pileatus). Species such as grey squirrel benefit from hard-mast production, but many species are affected adversely by low soft-mast and forage production.

Wildlife openings and rights-of-way lose their value as feeding and nesting areas for species like turkey and rabbits as woody vegetation encroaches. Since no management is done, few downed logs are created for sunning sites for reptiles or cover for amphibians, and few snags are created for raptors or cavity-nesting birds.

Threatened, Endangered, Proposed, and Sensitive Species

Lack of vegetation management, particularly prescribed fire, prevents management of habitat for any species. Habitat is improved for some species but destroyed for others by high intensity wildfires. Many species, especially fire-dependent species like the red-cockaded woodpecker decline. Although extinction is improbable as long as populations exist on State or private lands, recovery becomes unlikely as habitat suitability declines.

Soil

Fire protection combined with lack of underburns allows wildfire hazard to increase in some fuel types through progressive fuel buildup. Wildfires are estimated to burn about 3.8 times the present number of acres. Some of these acres are severely burned, resulting in impaired soil productivity.

Water and Aquatic Life

The increase in severe wildfires mentioned above increases stormflows and sediment yields in some areas.

Wildfire and Air Quality

Prescribed fire is not used, so wildfires are estimated to increase to at least 3,800 acres per year and are more intense in some fuel types. Annual smoke emissions from national forests are estimated at 1,900 tons per year, all from wildfires.

Visual Quality

Lack of treatment allows vegetation to encroach on views and vistas. Open, parklike areas eventually disappear with encroachment of midstory and understory vegetation. Wildfires are more intense, which increases mortality and creates a negative visual effect.

Cultural Resources

Risk of damage to cultural resources is low because no treatments are allowed. There is an increased risk of damage from wildfires in some fuel types.

Socioeconomic Conditions

Alternative A directly benefits those who enjoy a primitive forest setting, and negatively affects those who enjoy more rural settings. Social conflict is expected because of the magnitude of the change from current actions, and the perception that one group is receiving most benefits while another is suffering most losses. Employment opportunities and direct costs are lowest. Output of managed resources declines substantially.

Alternative B

Vegetation management is restricted to treatments that achieve minimum resource objectives. Minimum risk herbicides are applied only by hand. Only low disturbance mechanical tools and low intensity prescribed fire are used. Projected areas treated per year total 58,815.

Human Health and Safety

Herbicides applied exclusively by manual methods cause a somewhat greater health risk to individual workers than at present. Margins of safety for all chemicals are lowest for this type of application. Low level of herbicide usage, however, should cause low total worker and public exposure to herbicide.

Low level of herbicide use in this alternative means that other methods are used to accomplish vegetation management goals. Other methods have a higher rate of accident occurrence than herbicides, so a relatively high rate of injury is expected. No risk from other methods is expected for the public.

Distributions of accidents by cause and frequency are not expected to change from present. About 20 percent less acreage is treated than at present, which results in fewer total accidents.

Vegetation

Application of herbicides to 10,925 acres results in minimal loss of non-target plants; effects on non-target vegetation is lower than at present due to the use of more selective tools and the lesser number of acres treated.

Prescribed burning for fuel reduction projected to occur on a 7-year cycle marginally controls the buildup of hazardous fuels. Low intensity dormant season burns at this cycle produce a mix of woody and herbaceous species with a greater number of woody species growing into the understory and midstory. Herbaceous species decrease in number.

Mechanical tools causing only low soil disturbance are used. Herbaceous species initially increase, then after approximately 3 years begin to decline. Woody species initially decline but most recover within 5 years. Mortality of woody species due to uprooting is very low.

On manually treated areas repeated treatments must occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings due to the rapid growth of single and multiple sprouts on most cut hardwood stems.

Wildlife

Fire-dependent species benefit more in this alternative than in A since nearly 22,000 acres of prescribed burning for wildlife and T&E species occurs. Maintained rights-of-way produce habitat and some "edge" for species like rabbits.

Threatened, Endangered, Proposed, and Sensitive Species

Prescribed fire, manual and selective herbicide methods are available for T&E species habitat management. Mitigation measures assure adequate inventory of proposed, sensitive, threatened, and endangered species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 3 years in habitat for threatened and endangered species, 6 years in wildlife and range habitat, and 7 years for fuel reduction. Slash burns occur on a projected 4,769 acres per year and are estimated to be 70 percent light and 30 percent moderate. Piling and raking are not used.

Moderate slash burns and 3 year underburns pose low risk to productivity of poor soils only. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 789 acres.

Underburns for hazardous fuel reduction are planned for only 50 percent of the present acres. Therefore, wildfire hazard increases in some areas through progressive fuel buildup. Wildfires are estimated to burn about 2.4 times the present number of acres. Some acres are severely burned, resulting in impaired soil productivity.

Water and Aquatic Life

Nearly all sediment is caused by non-manual site preparation (projected 14,763 acres per year). Treatment intensity is low, producing about 160 tons of sediment per year; this is 0.6 percent of natural sediment yield from the national forests. Effects on stormflows and herbicide concentrations are minimal.

Wildfire and Air Quality

Each year, slash burns are projected to occur on 4,769 acres, underburns on 30,693 acres, and wildfires on 2,400 acres. Annual smoke emissions from national forests are estimated at 5,600 tons from prescribed fire and 1,100 tons from wildfire, for a total of 6,700 tons.

Visual Quality

Visual impacts are minimal and activities are performed to meet established visual-quality objectives. Some vistas and open parklike stands may be closed due to limited treatments.

Cultural Resources

The two methods with high risk, mechanical and fire, are utilized at acre levels and intensities substantially below current, so risk to cultural resources is quite low.

Socioeconomic Conditions

Alternative B primarily benefits those who enjoy primitive forest settings, and negatively affects those who enjoy more rural settings. Some social conflict is expected due to the change from current actions, and the perception that one group receives more benefits while another suffers more losses. Employment opportunities are lowest of all alternatives where management is done. Total cost is $1.88 million and per acre costs are $31.86. Managed outputs decline from present levels.

Alternative C

This alternative continues present levels of treatment specified in the Forest Land and Resource Management Plans. Herbicides are applied by hand and machine. Mechanical tools cause low to moderate disturbance. Prescribed fire is of low to high intensity. Projected acres treated per year total 101,247.

Human Health and Safety

Typical herbicide use levels pose no health risk to the public. At maximum use rates, several of the herbicides pose risks to workers and the public. About 9 vegetation management related injuries occur per year, and about half of them are serious.

Vegetation

Use of broadcast treatments on 30 percent of the even-aged pine site preparation and timber stand improvement areas, as well as 10 percent of the uneven-aged pine site preparation areas has moderate potential for damage to non-target vegetation. Herbicides are used on 28,404 acres. Temporary reduction of competing vegetation is achieved. Broadcast treatments generally increase herbaceous species and reduce woody species.

Prescribed burning at a 6-year cycle adequately controls the buildup of hazardous fuels. Growing and dormant season burns are used to produce a mix of woody and herbaceous mid- and understory species. Where growing season burns are used a greater number and variety of herbaceous species will be produced. Use of higher-intensity fire in this alternative further reduces woody species and increases herbaceous species. Range burns on a 5-year cycle sustain a mix of preferred range forage species consisting of native grasses, forbs, and legumes.

Mechanical tools causing low to moderate soil disturbance are used . Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations produce a greater decline. Some mortality of woody species occurs through uprooting by disking. Most woody species fully recover within 5 to 10 years following treatment.

Moderate amounts of manual methods are used, causing repeated treatments on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings. No biological methods are used.

Wildlife

A wide range of vegetation management tools provides a variety of habitats and successional stages for many species. Deer and turkey populations benefit from prescribed burning, opening maintenance, and other habitat improvement treatments. Prescribed burning frequencies are the same as alternative "E," but some intense burns occur, providing very early successional stage habitat. Mast producers are often not favored due to a higher use of non-selective treatments. Fewer snags for cavity nesters and downed logs for reptiles and amphibians are created than in alternatives "D" or "F."

Threatened, Endangered, Proposed, and Sensitive Species

All methods except biological and mechanical, are available for habitat management. Mitigation measures assure adequate inventory of threatened, endangered, proposed, and sensitive species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 3 years in habitat for threatened and endangered species, 5 years in wildlife and range habitat, and 6 years for fuel reduction. Slash burns occur on a projected 6,312 acres per year and are estimated to be 30 percent light, 50 percent moderate, and 20 percent severe. Piling occurs on a projected 35 acres per year.

Underburns, moderate slash burns, and piling pose low risk to productivity of poor soils only. Growing season underburns increase risk where they are used. Severe slash burns pose high risk on good soils and extreme risk on poor and fair soils. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 1,629 acres, high on 62,580 acres, and extreme on 13,080 acres; 2.8 percent of the national forests are seriously affected.

Water and Aquatic Life

Nearly all sediment is caused by non-manual site preparation (projected 23,926 acres per year). Treatment intensity is low to high, producing about 930 tons of sediment per year; this is 3.4 percent of natural sediment yield from the national forests. Effects on stormflows and herbicide concentrations are minimal.

Wildfire and Air Quality

Each year, slash burns are projected to occur on 6,312 acres, underburns on 50,917 acres, and wildfires on 1,000 acres. Annual smoke emissions from national forests are estimated at 8,700 tons from prescribed fire and 300 tons from wildfire, for a total of 9,000 tons.

Visual Quality

Visual impacts result mainly from prescribed fire, herbicide and mechanical methods. Visitors viewing treated areas see evidence of treatments up to 6 months, but degree of change meets retention to modification visual quality objectives.

Cultural Resources

Availability of high disturbance mechanical tools represents a relatively high potential for cultural resource damage on treated acres. Utilization of prescribed fire moderates possible effects from wildfire.

Socioeconomic Conditions

Alternative C provides some balance between those who enjoy a primitive or semi-primitive forest setting and those who enjoy more rural settings, though roaded-natural settings predominate. Some conflict exists at current levels. There is a high level of employment opportunity (though some alternatives have higher levels). Managed outputs are also relatively high. Per acre treatment costs average $34.47 and total costs are $3.5 million.

Alternative D

Herbicides are not used. Mechanical tools cause low to moderate disturbance. Prescribed fire is of low to moderate intensity. Projected acres treated per year total 101,247.

Human Health and Safety

No use of herbicides in this alternative means that other methods are used to accomplish vegetation management goals. Other methods, especially manual, have a higher rate of accident occurrence, so a relatively high rate of worker injury is expected. Public perception of safety improves. but worker safety declines while public safety is not affected.

Vegetation

Prescribed burning at a 6-year cycle adequately controls the buildup of hazardous fuels. Low to moderate intensity, growing and dormant season burns at these cycles produce a mix of woody and herbaceous mid- and understory species. Growing season burns, however, can be expected to produce a greater number and variety of herbaceous species. Range burns on a 5-year cycle sustain a mix of preferred range forage species consisting of native grasses, forbs, and legumes.

Mechanical tools causing low to moderate soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations (such as shearing and piling) produce a greater decline. Since no raking or heavy disking occurs, mortality of woody species through uprooting is very low. Woody species fully recover within 5 to 10 years following treatment.

The highest amounts of manual methods are used. Repeated treatments must occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings.

Areas using grazing as a biological method have some pine and hardwood seedling losses from plant injury and mortality. Heavy grazing intensities cause shifts in herbaceous species composition.

Wildlife

All methods except herbicides and biological, are available to manage for abroad range of wildlife species. High use of mechanical tools creates habitat for species which use very early successional stage habitat. The 5 year prescribed burning cycle for wildlife improves habitat for fire-dependent species and is generally favorable for species needing soft-mast, such as deer and turkey. Absence of broadcast herbicide treatments favors hard- and soft-mast producers used by many species. Mechanical site preparation leaves fewer snags but creates more downed logs used by reptiles and amphibians, unless combined with slash burning.

Threatened, Endangered, Proposed, and Sensitive Species

All methods but herbicides and biological are available for habitat management. Mitigation measures assure adequate inventory of threatened, endangered, proposed, and sensitive species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 3 years in habitat for threatened and endangered species, 5 years in wildlife and range habitat, and 6 years for fuel reduction. Slash burns occur on a projected 14,582 acres per year and are estimated to be 50 percent light and 50 percent moderate. Piling occurs on a projected 55 acres per year. Livestock grazing is used for evenage pine release on a projected 1,043 acres per year.

Underburns, moderate slash burns, and piling pose low risk to productivity of poor soils only. Growing season underburns increase risk where they are used. Biological methods pose low risk from overgrazing. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 66,372 acres. No soils are seriously affected.

Water and Aquatic Life

Nearly all sediment is caused by non-manual site preparation and biological pine release (projected 20,289 and 1,043 acres per year, respectively). Herbicides are not used, so their effects are nil. Treatment intensity is low to moderate, producing about 710 tons of sediment per year; this is 2.6 percent of natural sediment yield from the national forests. Effects on stormflows are minimal.

Wildfire and Air Quality

Each year, slash burns are projected to occur on 14,582 acres, underburns on 51,316 acres, and wildfires on 1,000 acres. Annual smoke emissions from national forests are estimated at 11,900 tons from prescribed fire and 300 tons from wildfire, for a total of 12,200 tons.

Visual

Visual impacts result from prescribed fire, manual, and mechanical treatments. Visitors viewing treated areas see vegetation disruption and ground disturbance up to 6 months after treatments. Treatments normally meet retention to maximum modification visual quality objectives.

Cultural Resources

Risks to cultural resources are highest of all alternatives due to reliance on mechanical tools which penetrate soil and there is a very slight increase in risk from prescribed fire.

Socioeconomic Conditions

Alternative D balances primitive or semi-primitive and rural settings. Some social conflict exists due to increased use of fire, manual and mechanical methods and the lack of herbicide use. Employment opportunities are only slightly higher than current due to a lower expenditure for treatments. Outputs are at Plan levels. Per acre costs are $28.87, and total costs are $2.9 million.

Alternative E

Use of mechanical methods, especially soil-disturbing tools, is reduced. Minimum risk herbicides are applied by hand and machine. Only low disturbance mechanical tools are allowed. Prescribed fire is of low to moderate intensity. Projected acres treated per year total 101,247.

Human Health and Safety

Herbicide use is essentially unchanged from the present (see alternative C). Additional mitigation required improves protection of both worker and public health from the present.

Increased manual treatments result in a slight increase in risk of worker accident which is offset by a decrease in fire related injuries due to the decrease in the use of fire as a tool.

Vegetation

Effects of herbicide use is essentially the same as for the current program. Slight increase in the number of treated acres results in a very slight increased risk to non-target plants. Temporary reduction in the amount and type of competing vegetation is achieved.

Prescribed burning at a 6-year cycle adequately controls the buildup of hazardous fuels. Low to moderate intensity, growing and dormant season burns at these cycles produce a mix of woody and herbaceous mid- and understory species. Growing season burns, however, can be expected to produce a greater number and variety of herbaceous species. Range burns on a 5-year cycle sustain a mix of preferred range forage species consisting of native grasses, forbs, and legumes.

The use of soil-disturbing mechanical tools in even-aged site preparation and to a lesser extent wildlife opening maintenance is sharply reduced in this alternative.

Mechanical tools causing only low soil disturbance are used. Herbaceous species initially increase, then after approximately 3 years begin to decline. Woody species initially decline but most recover within 5 years. Mortality of woody species due to uprooting is very low.

Moderate amounts of manual methods are used, causing repeated treatments on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings. No biological methods are used.

Wildlife

Moderate use of manual and lower use of mechanical tools should selectively favor more hard- and soft-mast producing woody plants. Adverse effects on mast producers from herbicides are greater than in alternative B but less than in alternatives C, G, and H. Methods used create less habitat for species such as quail, which use very early successional stage habitat, than intensive mechanical tools. Fire-dependent species benefit from an extensive burning program on a 5-year cycle, which improves browse, forage, and soft mast production.

Threatened, Endangered, Proposed, and Sensitive Species

All methods except mechanical and biological are available for habitat management. Mitigation measures assure adequate inventory of threatened, endangered, proposed, and sensitive species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 3 years in habitat for threatened and endangered species, 5 years in wildlife and range habitat, and 6 years for fuel reduction. Slash burns occur on a projected 7,416 acres per year and are estimated to be 50 percent light and 50 percent moderate. Piling is not done.

Underburns and moderate slash burns pose low risk to productivity of poor soils only. Growing season underburns increase risk where they are used. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 1,869 acres. No soils are seriously affected.

Water and Aquatic Life

Nearly all sediment is caused by non-manual site preparation (projected 23,046 acres per year). Treatment intensity is low to moderate, producing about 430 tons of sediment per year; this is 1.6 percent of natural sediment yield from the national forests. Effects on stormflows and herbicide concentrations are minimal.

Wildfire and Air Quality

Each year, slash burns are projected to occur on 7,416 acres, underburns on 50,950 acres, and wildfires on 1,000 acres. Annual smoke emissions from national forests are estimated at 9,200 tons from prescribed fire and 300 tons from wildfire, for a total of 9,500 tons.

Visual

Visual impacts result from prescribed fire, herbicide, and mechanical treatments. Visitors viewing the treated areas see significant vegetation disruption up to 6 months after treatments. Treatments normally meet retention to modification visual quality objectives.

Cultural Resources

Risks to cultural resources are very low because utilization of soil-penetrating tools is reduced to about one-tenth current levels.

Socioeconomic Conditions

This alternative is similar to the current situation with respect to user expectations but lack of some mechanical tools causes indirect costs to rise whenever substitute tools obtain less-than-satisfactory results. Employment opportunities also approximate current. Outputs are at Plan levels. Total costs are $3.41 million, per acre costs are $33.62.

Alternative F

Use of herbicides and mechanical methods is reduced. Minimum risk herbicides are applied by hand and machine. Mechanical tools cause low to moderate disturbance. Prescribed fire is of low to moderate intensity. Projected acres treated per year total 101,247.

Human Health and Safety

Mix of herbicide application tools and restricted amount of herbicide treatment keep herbicide-related health risks low. Increased hand-tool work results in a high rate of accidental lacerations from chain saws and cutting tools.

Vegetation

The overall effect of herbicide use on vegetation is less than for either C, E, G, and H due to the reduced number of acres (24,270) treated and the types of tools allowed. Also contributing to a lessened effect is an increase in the proportion of selective treatments over present in even-aged pine site preparation and timber stand improvements, Forest Service roads, county/State roads, railroads, and utility lines (oil/gas).

Prescribed burning at a 6-year cycle adequately controls the buildup of hazardous fuels. Low to moderate intensity, growing and dormant season burns at these cycles produce a mix of woody and herbaceous mid- and understory species. Growing season burns, however, can be expected to produce a greater number and variety of herbaceous species. Range burns on a 5-year cycle sustain a mix of preferred range forage species consisting of native grasses, forbs, and legumes.

Mechanical tools causing low to moderate soil disturbance are used . Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations (such as shearing and piling) produce a greater decline. Since no raking or heavy disking occurs, mortality of woody species through uprooting is very low. Woody species fully recover within 5 to 10 years following treatment.

Moderate use of manual methods in more areas causes a substantial increase in the amount of repeated treatments on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings. No biological methods are used.

Wildlife

Moderate use of manual and lower use of mechanical tools should selectively favor more hard- and soft-mast producing woody plants. Adverse effects on mast producers from herbicides are greater than in alternative B but less than in alternatives C, E, G, and H. Methods used create less habitat for species such as quail, which use very early successional stage habitat, than intensive mechanical tools. Fire-dependent species benefit from an extensive burning program on a 5-year cycle, which improves browse, forage, and soft mast production.

Threatened, Endangered, Proposed, and Sensitive Species

All methods except mechanical and biological are available for habitat management. Mitigation measures assure adequate inventory of threatened, endangered, proposed, and sensitive species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 3 years in habitat for threatened and endangered species, 5 years in wildlife and range habitat, and 6 years for fuel reduction. Slash burns occur on a projected 7,949 acres per year and are estimated to be 50 percent light and 50 percent moderate. Piling occurs on a projected 29 acres per year.

Underburns, moderate slash burns, and piling pose low risk to productivity of poor soils only. Growing season underburns increase risk where they are used. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 1,992 acres. No soils are seriously affected.

Water and Aquatic Life

Nearly all sediment is caused by non-manual site preparation (projected 22,965 acres per year). Treatment intensity is low to moderate, producing about 360 tons of sediment per year; this is 1.3 percent of natural sediment yield from the national forests. Effects on stormflows and herbicide concentrations are minimal.

Wildfire and Air Quality

Each year, slash burns are projected to occur on 7,949 acres, underburns on 51,270 acres, and wildfires on 1,000 acres. Annual smoke emissions from national forests are estimated at 9,400 tons from prescribed fire and 300 tons from wildfire, for a total of 9,700 tons.

Visual Quality

Visual impacts result from prescribed fire, herbicide use, and mechanical treatments. Visitors viewing the treated areas see vegetation disruption up to 6 months after treatments. Treatments normally meet retention to modification visual quality objectives.

Cultural Resources

Risks of effects on cultural resources are lower than current principally due to a reduction in use of soil-penetrating tools.

Socioeconomic Conditions

This alternative provides user settings comparable to current but reduces conflict by deemphasizing mechanical and herbicide treatments. Indirect costs and resource outputs are comparable to current, and there is no detectible change in employment opportunity. Per acre costs are $33.14, and total costs are $3.36 million.

Alternative G

Use of herbicides and mechanical methods is reduced. Minimum risk herbicides are applied by hand, machine, and helicopter. Mechanical tools cause low to moderate disturbance. Prescribed fire is of low to moderate intensity. Projected acres treated per year total 101,247.

Human Health and Safety

Approximately a 10% increase in herbicide use over present usage results in a slight increase in risk from present which is offset by improved mitigations required. Risk is at about current low level. A slight increase in risk results from increased mechanical tool use; risk still very low. Fire and manual tool use (high accident risk) are reduced which results in an overall reduction in worker accidents from the present.

Vegetation

Increase of about 10% in the use of herbicides and the inclusion of a limited amount of aerial application causes a slight increase in risk to non-target plants which is not completely offset by the increased proportion of selective tools used.

Prescribed burning at a 6-year cycle adequately controls the buildup of hazardous fuels. Low to moderate intensity, growing and dormant season burns at these cycles produce a mix of woody and herbaceous mid- and understory species. Growing season burns, however, can be expected to produce a greater number and variety of herbaceous species. Range burns on a 5-year cycle sustain a mix of preferred range forage species consisting of native grasses, forbs, and legumes.

Effects are similar to alternative "D," but occur on less acres than "D." Mechanical tools causing low to moderate soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations (such as shearing and piling) produce a greater decline. Since no raking or heavy disking occurs, mortality of woody species through uprooting is very low. Woody species fully recover within 5 to 10 years following treatment.

Manual methods decrease from present. Where used, some repeated treatments will occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedling or saplings due to the rapid growth of single and multiple sprouts on cut stems.

Areas using grazing as a biological method have some pine and hardwood seedling losses from plant injury and mortality. Heavy grazing intensities cause shifts in herbaceous species composition.

Wildlife

An increase in herbicide use reduces hard- and soft-mast producers used by many animals including deer, turkey, and squirrel on some sites, but use of selective herbicide methods favors mast producers on others. Prescribed burning frequencies and intensities produce effects similar to alternatives E and F. Increased use of mechanical tools leaves less snags for raptors but more downed logs for reptiles and amphibians.

Threatened, Endangered, Proposed, and Sensitive Species

All methods except biological are available for habitat management. Mitigation measures assure adequate inventory of threatened, endangered, proposed, and sensitive species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 3 years in habitat for threatened and endangered species, 5 years in wildlife and range habitat, and 6 years for fuel reduction. Slash burns occur on a projected 5,862 acres per year and are estimated to be 50 percent light and 50 percent moderate. Piling occurs on a projected 44 acres per year, and livestock grazing for evenage pine release on a projected 469 acres per year.

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Underburns, moderate slash burns, and piling pose low risk to productivity of poor soils only. Growing season underburns increase risk where they are used. Biological methods pose low risk from overgrazing. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 29,649 acres. No soils are seriously affected.

Water and Aquatic Life

Nearly all sediment is caused by non-manual site preparation and biological pine release (projected 24,780 and 469 acres per year, respectively). Treatment intensity is low to moderate, producing about 520 tons of sediment per year; this is 1.9 percent of natural sediment yield from the national forests.

Effects on stormflows and herbicide concentrations are generally minimal. Aerial treatments, however, pose risk of accidental direct application of herbicides to some streams.

Wildfire and Air Quality

Each year, slash burns are projected to occur on 5,862 acres, underburns on 49,935 acres, and wildfires on 1,000 acres. Annual smoke emissions from national forests are estimated at 8,500 tons from prescribed fire and 300 tons from wildfire, for a total of 8,800 tons.

Visual

Visual impacts result mainly from prescribed fire, herbicide, and mechanical treatments. Visitors viewing the treated areas see significant vegetation disruption up to 6 months after treatments. Treatments normally meet retention to modification visual quality objectives.

Cultural Resources

Potential to affect cultural resources is higher than current but not as high as alternative D.

Socioeconomic Conditions

As in the current alternative, a range of user settings is provided. Conflict may be intensified by utilization of aerial application of herbicides even though limited. Resource outputs meet Plan objectives, but indirect costs are higher and employment opportunities are slightly lower than current. Total cost is $3.57 million, per acre costs are $35.37.

Alternative H

Vegetation management is done to achieve maximum vegetation control. Herbicides are broadcast at maximum effective rates by hand, machine, and helicopter. High disturbance mechanical tools and intense prescribed fire are used more frequently than at present. Projected acres treated per year total 126,156.

Human Health and Safety

Aerial application of herbicides reduces average risk to herbicide applicators. About one and a half times as much acreage, however, are treated than currently, so more workers are exposed and the probability of an accidental spill increases. Because effectiveness of control is the major concern, human health and safety are important but less emphasized.

Vegetation

Projected increase in acres treated using herbicides, and increased frequency and intensity of treatments, permit almost complete control of competing woody or herbaceous vegetation and puts non-target vegetation at highest risk. Herbicide application by helicopter, mechanical sprayers, or hand ground tools occurs on 41,533 acres. Aerial application occurs on utility rights-of-way, site preparation, and pine release areas.

Prescribed burning for fuel reduction projected to occur on a 4-year cycle more than adequately controls the buildup of hazardous fuels. Dormant season underburns at this cycle produce a mix of woody and herbaceous mid- and understory species. Reductions in some woody species reproduction and development occurs, and greater numbers of herbaceous species predominate. Use of higher intensity fire for both dormant and growing season burns also reduces woody species and increases herbaceous species. Range burns on a 4-year cycle maintain relatively high amounts of primarily grass species, as well as some forbs and legumes.

Mechanical tools causing low to high soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations produce a greater decline. Some mortality of woody species occurs through uprooting by raking and disking. Most woody species fully recover within 5 to 10 years following treatment.

Manual methods decrease the most from present. Where used, some repeated treatments will occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedling or saplings due to the rapid growth of single and multiple sprouts on cut stems.

Areas using grazing as a biological control method have some pine and hardwood seedling losses from plant injury or mortality. Heavy grazing intensities cause shifts in herbaceous species composition.

Wildlife

Maximum vegetation control limits production of hard and soft mast used by deer, turkey and other species. Higher burning intensity and frequency combined with herbicide treatments severely reduce hardwood midstories used by songbirds like tufted titmouse (*Parus bicolor*), but may increase soft mast production. Snags for raptors and downed logs for reptiles and amphibians are less available than in other alternatives.

Threatened Endangered, Proposed, and Sensitive Species	All methods except biological are available for T&E species habitat management. Mitigation measures assure adequate inventory of proposed, sensitive, threatened, and endangered species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.
Soil	Underburns occur every 3 years in habitat for threatened and endangered species and 4 years for wildlife and range habitat and fuel reduction. Slash burns occur on a projected 6,312 acres per year and are estimated to be 20 percent light, 50 percent moderate, and 30 percent severe. Piling and raking occur on a projected 306 and 308 acres, and livestock grazing for evenage pine release on a projected 807 acres, per year. Underburns, moderate slash burns, and piling pose low risk to productivity of poor soils only. Growing season underburns increase risk where they are used. Severe slash burns and raking pose high risk on good soils and extreme risk on poor and fair soils. Biological methods pose low risk from heavy grazing. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 52,401 acres, high on 109,440 acres, and extreme on 22,740 acres; 4.9 percent of the national forests are seriously affected.
Water and Aquatic Life	Nearly all sediment is caused by non-manual site preparation and biological pine release (projected 25,546 and 807 acres per year, respectively). Treatment intensity is low to high, producing about 1,720 tons of sediment per year; this is 6.4 percent of natural sediment yield from the national forests. Effects on stormflows and herbicide concentrations are generally minimal. Aerial treatments, however, pose the greatest risk of accidental direct application of herbicides to some streams.
Wildfire and Air Quality	Each year, slash burns are projected to occur on 6,312 acres, underburns on 67,112 acres, and wildfires on 1,000 acres. Annual smoke emissions from national forests are estimated at 9,600 tons from prescribed fire and 300 tons from wildfire, for a total of 9,900 tons.
Visual Quality	This alternative creates significant visual impacts with more treatment acres meeting the maximum modification visual quality objective. Prescribed fire, mechanical, and herbicide treatments are used more and at higher intensity. These increases result in significant color and textural changes readily noticed by visitors, lasting up to 1 year. Individual treatment effects may not meet the assigned visual quality objective.

Cultural Resources

Though the full range of mechanical tools is available, use of those which penetrate soil is less extensive than current so potential effect on cultural resources is moderate. Fire treatments pose a higher risk of negative effects.

Socioeconomic Conditions

Alternative H directly benefits those who enjoy a rural forest setting, and negatively affects those who enjoy more primitive settings. Social conflict is caused by the magnitude of the change from current actions, and the perception that one group was receiving most of the benefits while another was suffering most of the losses. Employment opportunities are higher than current due to more treated acres. Outputs exceed Plan levels. Total costs are $4.22 million, per acre costs are $33.64.

N. RESEARCH NEEDS

No critical information is missing that would prevent implementation of any alterantive in this EIS. However, the analysis did reveal a need for more research was identified in several areas.

Research is an integral part of work done on national forests and is used to acquire knowledge of environmental processes and relationships. Information concerning effects of vegetation management, derived from existing research studies, form the basis for most of the conclusions of this document.

Following are the major research needs identified. Only items 1 through 5 relate to incomplete or unavailable information identified as data gaps in sections B, D, F, and G of this chapter (40 CFR 1502.22). Items 6 through 19 are other important research needs.

1. Public, worker, and wildlife exposure from use of different herbicides and application rates.

2. Synergistic and cumulative effects of herbicides.

3. Herbicide effects on wildlife, including effects on habitat, chronic toxicity, and oncogenic and mutagenic potential.

4. Long-term effects on soil and water from varying severity of slash burns and from varying frequency and season of underburns.

5. Effects of vegetation management methods on streamflows and channel erosion, and rates of channel erosion in undisturbed forests.

6. Effects of prescribed burning on growth of different size classes of yellow pines.

7. Effects of alternating dormant and growing season burns on plant communities.

8. Effectiveness of prescribed fire in promoting advanced oak regeneration in cove sites and producing quality hardwood sprouts.

9. Effects of long-term periodic underburns in upland pine, pine-hardwood, hardwood-pine, and hardwood stands on stand quality; and understory species composition.

10. Composition, interrelationships, and potential indicator species of understory plant communities.

11. Long-range (multi-rotational) effects on wildlife and plants (especially threatened, endangered, proposed, and sensitive species) from vegetation management, including growing and dormant season burns.

12. Relationship of prescribed fire effects on wildlife (especially reptiles, amphibians, and songbirds) to fire behavior, including intensity, duration, and season.

13. Long-term effects on animals, especially threatened, endangered, proposed, and sensitive species, associated with plant communities that are treated with specific combinations of herbicides and periodic fire.

14. Competition between wildlife and domestic animals for available vegetation.

15. Long-term effects of intensive mechanical site preparation on soil, water, reptiles, and amphibians.

16. Movement of all 11 herbicides to streams and ground water, using typical application rates, over the full range of application methods and soil, geologic, and topographic conditions in the South.

17. Effects of increased sediment yield on aquatic species and their habitats.

18. Effects of prescribed fire on wildfire occurrence and air quality both locally and regionally.

19. Relationships between air pollution, CO_2 production, ozone layer depletion, and plant growth and reproduction.

20. Effectiveness of biological vegetation controls, including light inhibitors, livestock, insects, and allelopathic plants.

O. ENERGY REQUIREMENTS

The principal energy source for vegetation management is fossil fuel. Every alternative except A consumes fuel (usually petroleum) either directly, such as in vehicles, machinery and equipment, or indirectly, such as an ingredient in herbicides or in a manufacturing process.

Another energy source which is sometimes consumed is logging debris which has potential household or industrial uses.

Energy requirements for vegetation management are only a small part of the total energy required for all management activities occurring on national forests. While there are variations between alternatives (A uses none, B requires the least, and H requires the most), these variations are not significant.

P. POSSIBLE CONFLICTS WITH OTHERS

Other local, State and Federal agencies have vegetation management programs of their own and may be affected by actions done under the preferred alternative. Some of these agencies have overlapping responsibilities with the Forest Service, and some have administrative authorities to prescribe limits on certain types of adverse effects.

None of these agencies asked to be a "cooperating agency" under the provisions of the National Environmental Policy Act. However, many have participated in the preparation of this environmental impact statement:

- The Environmental Protection Agency has provided information on environmental standards and testing procedures.
- The Fish and Wildlife Service has assisted with data and requirements for compliance with the Endangered Species Act.
- The Tennessee Valley Authority has assisted with rights-of-way analysis and provided cost statistics.
- Finally, chapter VI contains a list of numerous agencies at all levels which will review this document.

Few apparent conflicts with others have been noted. One is that management intensities on national forests can be expected to differ from intensities on other lands. Privately-owned lands are managed for many different purposes, and even Federally-managed lands nearby can be expected to be different. National Parks, for example, are managed for altogether different objectives than National Forests. The uninformed visitor could have unrealistic expectations that all lands should have similar management, particularly when they are adjacent. Management intensities will differ depending on the mission and objectives of the responsible agency or private landowner.

Alternatives A and B reduce payments to local governments relatively quickly. Selection of either of these alternatives requires more intense coordination with these governments because both of these alternatives envision substantial program revisions.

Conflicts will occur with Forest Land and Resource Management Plans. Plans assumed that all vegetation management methods are available. The Regional Forester's decision about which mix of methods to use, based on this analysis, could be different from assumptions in Plans. Forest Supervisors will evaluate the Regional Forester's decision and its effect on Plans and make changes as needed. The Forest Service will use and incorporate by reference any relevant information from this EIS and those accompanying Plans when conducting site-specific analyses for vegetation management projects.

Q. ADVERSE EFFECTS THAT CANNOT BE AVOIDED

Despite mitigation measures, some significant adverse effects are unavoidable, some in alternative A only, and some in any alternative where vegetation management is done. These effects are:

1. Health and Safety

Worker accidents occur through use of vegetation management methods, especially manual methods and prescribed fire.

2. Vegetation

Individual non-target plants are injured or killed by vegetation management. Some methods and tools have greater effects than others; intensive broadcast treatments have the greatest effect.

3. Wildlife and Aquatic Animals

Wildlife requiring mature forests is displaced or lost from some habitats by vegetation management which prolongs early stages of plant succession. Wildlife requiring open areas is displaced as young stands age, especially in alternative A.

4. Threatened, Endangered, Proposed, and Sensitive Species

Lack of vegetation management in alternative A reduces populations or prevents recovery of some animals and plants that can exist only in forests experiencing periodic disturbances.

5. Soil

Soil productivity is impaired where intensive prescribed fire or mechanical methods cause excessive loss of soil organisms, organic matter, and nutrients in alternatives C and H.

6. Water

Water quality is impaired in some small streams that drain areas where high disturbance tools are used in alternatives

	C and H, or that are accidentally overflown during aerial herbicide application in alternatives G and H.
7. **Air Quality**	Smoke from prescribed fires or wildfires temporarily impairs air quality in every alternative.
8. **Rights-of-Way**	Lack of treatment in alternative A allows vegetation to encroach on rights-of-way, threatening public safety on roads and trails and impairing operation of utility lines.
9. **Visual Quality**	Visual quality is temporarily impaired by vegetation management methods. Lack of treatment in alternative A may also cause impairment.
10. **Wildfire**	Lack of prescribed fire in alternative A allows fuels to build to dangerous levels in some fuel types and increase probability and severity of wildfire damage.

11. **Socioeconomic Conditions**	Any action or lack of action is acceptable to some people and unacceptable to others. This disagreement creates social conflict about vegetation management. Conflict is created whenever there are changes from current ways of doing things.

R. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

An irreversible commitment is one in which nonrenewable resources are permanently lost. Such losses occur when oil, gas, coal, or petroleum products are consumed and cannot be replaced. Some endangered plants occurring only on national forests may be irreversibly lost in alternative A. Soil productivity may be impaired for many decades on sites where raking or severe slash burns are used in alternatives C and H.

An irretrievable commitment is one in which resource production or use is lost while managing an area for another purpose. If we choose not to manage a resource, we do so knowing we lose its potential value had it been managed. All alternatives eliminate or reduce management of some resources, while emphasizing others.

This EIS makes no irreversible or irretrievable commitment of resources. It displays the projected effects of vegetation management for the activities listed in chapter I. Any irreversible or irretrievable commitment of resources will occur at the site-specific level and be accompanied by site-specific analysis that discloses the environmental effects.

S. SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

National forests must be managed to protect long-term productivity of the land. Long-term productivity is the capability of forests to provide resources into the future. Most management activities and resource outputs are short-term uses. When decisions are made to produce these outputs, long-term productivity could be affected. Generally, mitigation measures reduce or eliminate effects on long-term productivity by protecting soil, water, wildlife, and threatened and endangered plants and animals. Where raking or severe slash burns are used, however, loss of long-term soil productivity is inevitable.

Monitoring requirements which apply to all alternatives are designed to provide feedback to managers who ensure that long-term productivity is not impaired by short-term uses. If monitoring discloses that management requirements and mitigation measures are inadequate, new ones will be developed.

List of Preparers

CHAPTER V

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LIST OF PREPARERS

A. INTERDISCIPLINARY TEAM SELECTION

The Regional Forester and his staff evaluated the need to prepare an environmental impact statement and identified activities which needed to be analyzed. Once analysis needs were known, a team leader was selected and the team leader and Regional Forester looked at the Region's work force to locate individuals with education and experience necessary to complete the analysis.

Team members listed below represent a broad mix of experience and specialized training. Specialties cover a wide range of resources and all members are highly experienced in natural resource and human resource management. The team prepared this EIS. Some of the work they did was identifying and examining issues, developing and evaluating alternatives, researching and analyzing environmental effects, and studying and responding to public comments.

B. FULL-TIME TEAM MEMBERS

Steve McCorquodale is the team leader. He has a Bachelor of Science degree in Forestry from McNeese State University at Lake Charles, Louisiana. Steve is completing his 25th year with the Forest Service and has had assignments in North Carolina, Texas, Virginia, Mississippi, Kentucky, Alabama, and Georgia. His principal area of expertise in fire management. In addition, his previous positions have given him responsible administrative and supervisory experience in recreation, silviculture, public affairs, minerals, and wilderness. Steve is an avid hunter and fisherman and pursues his interests in natural resources through active memberships in Society of American Foresters and American Forestry Association.

Interdisciplinary Team responsibilities include overall management and supervision as well as coordination with others and accountability to management.

Ann Cason is the program assistant. She has specialized secretarial education through several Office of Personnel secretarial, business management, and administration courses. Ann is completing her 26th year of Federal service and has had assignments with the Environmental Protection Agency, Department of Justice, U. S. Geological Survey, Department of Defense, and for the last eight years with the Forest Service. Assignments in positions such as administrative technician, clerk-stenographer, secretary, and executive secretary have given her broad administrative experience. Ann enjoys gardening and walking.

Her responsibilities on the team include internal and external scheduling, correspondence, computer management, financial management and travel coordination.

Jim Maxwell is the team hydrologist. He has a Bachelor of Science degree in Forest Hydrology from Utah State University at Logan, Utah. Jim is in his 19th year with the Forest Service and has had assignments in California, Utah, Idaho, West Virginia, Oregon, New Mexico, and Georgia. His principal area of expertise is in streamflow-sediment dynamics. In addition his previous positions have given him supervision and administration experience in stream and fisheries protection, rainfall-runoff relationships, and influence of climate. Jim is an avid hiker and river floater.

Responsibilities as a team member are for analysis of soil, water and air resources and evaluation of cumulative effects.

Paul A. Mistretta is the team plant pathologist. He has a Bachelor of Science degree in Biology from Fordham College, New York, New York, a Master of Forestry degree (forest protection) from Duke University, Durham, North Carolina, and a Doctor of Philosophy in plant science from the University of Maine at Orono. Paul is in his 13th year with the Forest Service and has had assignments in Georgia and Louisiana. His principal area of expertise is in epidemiology of forest tree diseases. He also has two years experience as a graduate teaching assistant. He has authored or coauthored over 40 publications and is active in several professional societies. Paul enjoys philately and computer programming.

Responsibilities as a team member are for coordination of risk assessment, toxicology and rights-of-way analyses and incorporation of those analyses into the EIS.

Jane Sell is the editorial assistant. She has enhanced her skills through on-the-job training. Jane is in her 17th year with the Forest Service and has had assignments as clerk-typist and clerk-stenographer. Her experience as owner-operator of a printing company for 12 years and additional administrative-editorial experience with other environmental documents with the Forest Service give her broad qualifications. Jane actively pursues outdoor sports.

Team support responsibilities are to manage filing and data systems, to assist with edit and layout, and to coordinate literature search.

Gary Sick is the team public affairs specialist. He has a Bachelor of Science degree in Geological Sciences from the State University of New York at Geneseo, New York and a Master of Science degree in Forestry (policy analysis) from Michigan State University at East Lansing, Michigan. Gary is in his 12th year with the Forest Service and has had assignments in Mississippi, Arkansas, Michigan and Georgia. His principal area of expertise is in minerals management. In addition, his previous positions have given him responsible management experience in data management, environmental planning, and water quality analysis. Earlier experience includes three years in social work and one year in public schools. Gary enjoys most outdoor recreation, especially fishing.

Responsibilities on the team are NEPA compliance, scoping, media and document production.

Cynthia A. Witkowski is the team silviculturist. She has a Bachelor of Science degree in Natural Resource Conservation from the University of Connecticut at Storrs, Connecticut. Cindy is in her 13th year with the Forest Service and has had assignments in South Carolina, Arkansas, Louisiana and Georgia. Her principal area of expertise is in timber and silviculture. Her positions have also given her responsible management experience in administration, recreation, minerals, wildlife and human resources. Two years with the Peace Corps also gave her broad natural resource management skills. Cindy enjoys golf and fishing and is an active member of the Society of American Foresters.

Team responsibilities are analysis and coordination of silviculture, wildlife and range.

C. PART-TIME TEAM MEMBERS

Danny Ebert is the team fisheries biologist. He has a Bachelor of Science Degree in Biological Science from Bowling Green University, a Master of Science Degree in Fisheries Science from the University of Southern Mississippi, and has worked on his Doctorate Degree in Fisheries Science and Stream Ecology at Virginia Tech University and the University of Arkansas. Danny has 11 years experience with the U. S. Forest Service in Mississippi, Louisiana, and Arkansas. He has taught several fisheries courses at Arkansas Tech University since 1985 as an adjunct professor in Fisheries and Wildlife Science. Danny's principal area of expertise is cool water and warm water stream ecology and fisheries. He also has experience with threatened and endangered species, reservoir management, and range and wildlife management. Danny is a Certified Fisheries Scientist in the American Fisheries Society, and belongs to numerous scientific and popular fisheries organizations. He enjoys jogging, racket sports, and spending time at home with his family.

Team responsibilities are for analysis of vegetation management effects on aquatic species, both vertebrate and invertebrate, and their habitats.

Richard Greenhalgh is the Southern Region's economist, and provides economic analysis support on a part-time basis. He has a Bachelor of Science degree in Vocational Education and a Master of Science degree in Agricultural Economics from University of Nebraska, and a Doctor of Philosophy with emphasis in Natural Resource Economics from the University of Missouri. His experience includes 15 years of research and river basin studies throughout the Southeast with the USDA Economics Research Service, and 10 years as an economist with the Forest Service.

Charles K. McMahon is supervisory research chemist/project leader; USDA Forest Service, G.W. Andrews Forestry Sciences Laboratory, Auburn University, Alabama. Charles holds a Bachelor of Science from St. Peter's College, a Master of Science degree in chemistry from Rutgers University and a Master's degree in Management from Georgia College. Charles began his Federal career in 1963 as an environmental chemist with the Department of the Army in Salt Lake City and Dugway, Utah. In 1973 he transferred to the U. S. Forest Service, Southeastern Forest Experiment Station, at the Southern Forest Fire Laboratory in Macon, Georgia. In 1987 he transferred to his current position in Auburn with the Southern Forest Experiment Station. Charles's current research is concentrated on the interaction of fire and forest herbicides, worker safety, and the air quality impacts of vegetation management practices. He is a member of the Air Pollution Control Association, American Chemical Society, American Industrial Hygiene Association, and the American Geophysical Union. He is a Fellow of the American Institute of Chemists and a Certified Professional Chemist.

Program responsibilities include analysis of potential air-quality impacts of vegegation management practices.

Jerry Lee Michael holds a B.S. in chemistry from Elon College, master's degree in plant taxonomy from the University of North Carolina at Chapel Hill, and a Doctor of Philosophy in tree physiology from Colorado State University.

He spent two years in the army as a plant physiologist at Fort Detrick, Maryland. After completing his Ph.D. at Colorado, he went to the University of Georgia as a post-doctoral fellow where he worked on host-physiology related aspects of the southern pine beetle problem and on the physiology of paraquat induced resin soaking in southern pines. He is currently employed by the Southern Forest Experiment Station, Forest Service at Auburn University, Auburn, Alabama. His primary work has been research on environmental chemistry of the principal herbicides used in forestry including the immediate and ultimate fate of herbicides applied to forest ecosystems.

Responsibilities as a part-time team member are for analysis and evaluation of herbicide effects.

Dan Neary is the team soil scientist. He has a Bachelor of Science degree in Forestry, a Master of Science degree in Forest Ecology, and a Doctor of Philosophy degree in Forest Soils and Hydrology, all from Michigan State University at East Lansing. Dan is in his 12th year with the Forest Service. He has had assignments with the New Zealand Forest Research Institute and the Cowetta Hydrologic Laboratory, North Carolina, and is currently part of the Intensive Management Practices Assessment Center, Southeastern Forest Experiment Station at the University of Florida. His principal area of expertise is in the environmental fate and effects of forestry pesticides, but he also has considerable experience with the effects of intensive forestry on soils, site productivity, and water quality. He has authored or co-authored over 65 publications, and is active in numerous scientific organizations. Dan enjoys swimming, sailing, and skiing.

Responsibilities as a part-time team member are for analyses and evaluation of herbicide effects, soil and water impacts, and cumulative watershed effects.

Carl Racchini is a wildlife biologist on the team. He has a Bachelor of Science degree in Wildlife Management and Biology from the University of Wisconsin, Stevens Point. Carl has 14 years with the Forest Service and has experience in Minnesota, Alaska, and Arkansas. His principal area of expertise is in forest wildlife management. His positions have also given him experience in fisheries, minerals, watershed, and human resource programs. Carl is an active member of Ducks Unlimited, Audubon Society, Wildlife Society and the Turkey Federation. He enjoys canoeing, photography, and hunting.

Team responsibility is analysis of effects on wildlife habitat.

Dennis Robertson has a Bachelor of Science degree in Landscape Architecture from the University of Missouri at Columbia, Missouri. He has completed his 22nd year with the Forest Service with assignments in Washington, Wyoming, Arkansas, and Georgia. His principal area of expertise is in resource planning. In addition, his previous assignments have given him responsible management experience in recreation management, facilities design, landscape management, and rights-of-way design.

Dennis enjoys many outdoor sports and yard work, and maintains an active membership in the National Arbor Day Foundation and National Recreation and Parks Association.

Responsibilities as a team member are for analysis of visual quality and rights-of-way maintenance techniques.

David Saugey has a Bachelor of Science degree in Biology from the University of Arkansas, Little Rock, Arkansas, and a Master of Science degree in Zoology from Arkansas State University, Jonesboro, Arkansas. David is completing his twelfth year with the Forest Service and has had assignments on both the Ozark and Ouachita National Forests in Arkansas. His principal areas of expertise are forest wildlife management and threatened, endangered and sensitive species. He served as the wildlife biologist for the reanalysis of the Land Management Plan of the Ouachita National Forest. In addition, his positions have given him responsible management experience in fire, range, watershed, and recreation. David has active memberships in the American Society of Mammalogists, Society for the Study of Amphibians and Reptiles, Natural Areas Association and other conservation organizations. He enjoys writing popular and scientific articles on non-game wildlife and photography.

Team responsibility is for analysis of effects on threatened, endangered and sensitive species.

Max Williamson is the Regional Pesticide Specialist. He has a Bachelor of Science degree in Chemistry from Cumberland College at Williamsburg, Kentucky, and the Master of Science degree in Environmental Engineering from Murray State University at Murray, Kentucky. He has completed additional graduate studies in Physical Sciences and Toxicology. He is in his 27th year with the Forest Service and has broad experience as a pesticide specialist and resource management. His assignments have been in California, Virginia, North Carolina, Arkansas, Oklahoma, and Georgia.

Responsibility as a team member is to serve in an advisory capacity, and to act as liaison with industry and regulatory bodies.

Tom Wiseman is a writer-editor with the team. He has a Bachelor of Arts degree in English from the Pennsylvania State University at University Park, Pennsylvania. He also earned a Master of Arts and a Ph.D in English from Tulane University in New Orleans, Louisiana. He served as writer-editor with the Forest Service's Southern Forest Experiment Station for 2 years. Additionally, he edited Forest Farmer magazine for 8 years. He is now assistant professor of English at Southern College of Technology in Marietta, Georgia. Tom enjoys fishing, coaching youth basketball, and creative writing.

Team responsibilities include copy editing and writing, assisting with layout and design, and proofreading.

D. ADVISORS, CONSULTANTS AND REVIEWERS

1. Advisors

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Jim Fenwood, USDA Forest Service, Fisheries and Wildlife
Chris Glover, USDA Forest Service, Systems Support
Harold Greenlee, USDA Forest Service, Geometronics
George Hemmingway, USDA Forest Service, Lands and Minerals
Bruce Jewell, USDA Forest Service, Public Affairs
Jean Kruglewicz, USDA Forest Service, NEPA Compliance
Yvonne Knaebel, USDA Forest Service, Appeals & Litigation
Jim Lunsford, USDA Forest Service, Fire
Keith McLaughlin, USDA Forest Service, Soil, Water and Air
Bob Stignani, USDA Forest Service, Recreation
Jimmy Walker, USDA Forest Service, Timber/Silviculture

2. Risk Assessment Review

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Jim Brewer, JLB International Chemicals
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Sean Casey, Elanco Products
Dave Clapp, Centers for Disease Control
Bob Cooke, USDI Fish and Wildlife Service
Edwin Dale, Private citizen
Ed Daley, International Paper
Tom Darden, USDA Forest Service
Dean Gjerstad, Auburn University
Jack Gnegy, Westvaco
Larry Gross, USDA Forest Service
Simon K. Hall, American Cyanamid
Zdenka Horakova, USDA Forest Service
George Hurst, Mississippi State University
Kentucky Power Co.
Kentucky Utilities Co.
Timothy J. Long, Montsanto Co.
Bob Lowery, Weyerhaeuser
Bill McComb, Oregon State University
Jerry L. Michael, USDA Forest Service
Hans Muller, US Environmental Protection Agency
Fredrick O. O'Neal, E.I. Dupont Co.
Bill Pope, Potlach
John Taylor, USDA Forest Service
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3. Technical Consultants and Review

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Art Cram, Private Citizen
George Dissmeyer, USDA Forest Service

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Eric Ellwood, North Carolina State University
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Steve Filipek, Arkansas Game and Fish Commission
Larry Flemming, USDA Forest Service
John Fortin, USDA Forest Service
Roger Fryar, USDA Forest Service
Hal Glassman, USDA Forest Service
William Goddard, USDA Forest Service
Robert K. Godfrey, Florida State University
Paul Hamel, Tennessee Department of Conservation
Dennis Harden, Florida Natural Resources Inventory
Gary Hasty, Tennessee Valley Authority
John Hosner, Virginia Tech.
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Bill Jones, Alabama Forestry Association
Dave Ketcham, USDA Forest Service
Ken Knauer, USDA Forest Service
Larry Landers, Tall Timbers Research Station
Gary Larsen, USDA Forest Service
Lee Lavdas, USDA Forest Service
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John Long, USDA Forest Service
Edwin Michael, West Virginia University
James Miller, USDA, Forest Service
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Bob Mitchell, Auburn University
Logan Norris, Oregon State University
Joe Nix, Private Citizen
Max Ollieu, USDA Forest Service
Dick Patton, USDA Forest Service
George Rogers, USDA Forest Service
Rhey Solomon, USDA Forest Service
Peter Sprints, Texas A&M
Richard Tallent, Tennessee Valley Authority
Ronald Thill, USDA Forest Service
Dale Wade, USDA Forest Service
Carol Wells, USDA Forest Service

Public Participation and Consultation With Others

CHAPTER VI

CHAPTER VI

PUBLIC PARTICIPATION AND CONSULTATION WITH OTHERS

A. PUBLIC INVOLVEMENT SUMMARY

Because vegetation management issues are often intense and sometimes emotional, a high level of public participation was deemed necessary for satisfactory completion of this environmental impact statement. Therefore, the public has been actively involved in its development. Many people and organizations made valuable contributions to the analysis.

The Forest Service has encouraged public participation throughout EIS preparation. Steps taken to keep the public informed and involved are:

Notice of Intent - A notice of intent to prepare this EIS was published in the September 11, 1986 Federal Register. A revised Notice of Intent, based on early scoping results, was published in the May 5, 1987 Federal Register. This revision described methods which would be evaluated, dates for public review of the draft statement and the completion date for the final statement.

Letter to the Public - The public was asked to identify issues through the use of a post-paid mailer designed for this project. Over 5,000 of these mailers were distributed to interested individuals, groups and agencies in June 1988. To obtain the broadest possible coverage, each forest assembled a list of every party known to them to be interested in national forest management. These lists were then merged into a master list.

Media - Radio, television and the press were included in the request for comments on issues. Additionally a press release was distributed: to regional media by the Regional Public Affairs Office, and to state and local media by individual Forest Public Affairs Offices. The press release was done at the same time as mailers were sent, June 1988.

Meetings - On several occasions between June 1988 and June 1989 members of the interdisciplinary team and designated forest representatives met or spoke with agencies, organizations and individuals whenever the level of interest was appropriate for this type activity. Needs varied from locality to locality.

Tabloid - In November 1988, 5000 tabloids containing information about the scope, timing and progress of the EIS were distributed. Also included in the tabloid were articles about issues, alternative themes, risk assessment, and some methods proposed for use. A post-paid return envelope was inserted in the tabloid to allow for additional public response. A coupon requesting a copy of the EIS or just inclusion on the mailing list was also printed to offer an opportunity to anyone who might not have already made the request.

Key Contacts - Other Federal agencies, Congressional delegations, State agencies, State lawmakers, other Forest Service Regions, and heads of organizations were contacted by phone and by letter to inform them of project initiation. Accompanying the letter was an informational brochure describing the scope of the EIS and responding to commonly asked questions.

Cooperators - No other Agencies requested formal cooperator status, though many were consulted and contributed to the analysis. A unique form of cooperation was implemented for the risk assessment. Other State and Federal agencies as well as several utility companies were offered an opportunity to expand the scope of the risk assessment (to evaluate additional herbicides used by them on their easements or permit areas on national forests). To do this they were required to fund the additional costs of analysis. Eleven utilities and the Tennessee Valley Authority elected to participate.

Responses - Public responses to the request for input on issues were catalogued into nine categories: elected officials; State and local government; Federal government; individuals; organizations; businesses; Forest Service employees; Forest Service retirees; and media. At the time of content analysis, September 1988, 270 responses had been received. Ultimately, the total number of responses and requests for information was 495. These responses originated in 32 States, the District of Columbia and Canada (see table VI-1 for a complete breakdown).

Of the 495 responses in the table, 392 or 79 percent came from States within the geographic area covered by this EIS.

To improve responsiveness and to enhance the analysis, working papers and partial drafts of many parts of the EIS were shared with cooperating agencies, working groups and citizens with special expertise throughout the process.

Scientific adequacy was ensured through an extensive system of review. Chapter V, D. lists reviewers and their affiliations. Unique qualifications of these people augment disciplines represented on the interdisciplinary team.

Table VI-1.--Response distribution - Ozark/Ouachita Mountains.

State	Elec Off.	St./Loc Gov't	Fed. Gov't	Individuals	Organizations	Businesses	Employees	Retirees	Media	Total
Alabama				2		1	2			5
Alaska				1		1				2
Arkansas	2	20	5	208	13	71	8	1	2	330
Arizona				3						3
California				1						1
Colorado					1					1
Connecticut				1						1
Florida				3	2		2			7
Georgia		2			2			1		5
Illinois				2						2
Iowa				1						1
Kansas				1						1
Kentucky				1						1
Louisiana				7	1	6				14
Maryland				1						1
Massachussetts							1			1
Michigan				1			2			3
Minnesota				1						1
Mississippi				3			1			4
Missouri				2		1			1	4
Montana							2			2
New Mexico			1	2						3
North Carolina				1		1	3			5
Oklahoma		5		51	1	2		2	1	62
Oregon				1			1			2
Pennsylvania		1								1
South Carolina				1			1			2
Tennessee		1		1			1			3
Texas				10						10
Utah							2			2
Virginia				1		1	1			3
Wisconsin							1			1
Washington, DC	6		1	1	1					9
Canada			1		1					2
Total	8	29	8	308	22	84	28	4	4	495

Responses were organized into about 150 groups based on methods and affected resources. These groups were then analyzed for major themes called issues (chapter I). Then, a number of alternatives (chapter II) were developed which were responsive to these issues.

The next step in public review is distribution of the Draft statement. Copies are sent to each of the 495 respondents as well as additional persons known to have an interest or required by regulations (chapter VI, part C).

B. CONSULTATION WITH OTHERS

One of the most important parts of the process of preparing this environmental impact statement is information gathering. Advice and contributions from experts are essential to a thorough and complete analysis. Chapter V lists over eighty individuals who contributed. Additionally, in many cases authors of research papers were consulted to clarify results of their analyses.

While all consultations helped shape the analysis contained in this document, some consultations resulted in specific significant direction on how to conduct the analysis.

Offices of the Environmental Protection Agency in Atlanta, Georgia and Washington, D.C. were consulted concerning analysis requirements, especially for water. They advised that cumulative effects be analyzed on typical, representative watersheds. They also advised that analysis of sediment loads consider potential effects on quality of fish habitat. The analysis in chapter IV models cumulative watershed effects as advised, and considers effects on fisheries.

Dow Chemical Company was consulted regarding the results of new tests on dermal penetration rates for triclopyr. These test results caused substantial revision of risk assessment.

The contractor responsible for preparation of the risk assessment, Labat-Anderson, Inc., routinely consulted with the Environmental Protection Agency regarding analytical protocol for the risk assessment, and to obtain toxicological are information. Data resulting from these consultations are reflected in the risk assessment.

C. LIST OF THOSE TO WHOM THIS DOCUMENT WAS SENT

International

Alberta Environmental Centre, Alberta, Canada
Canadian Wildlife Service, Ottawa, Canada

Businesses

Anna Giller Trust, El Dorado, AR
Anthony Timberlands, Inc., Little Rock, AR;
  Lake Hamilton, AR; Bearden, AR; Malvern, AR
Arkansas Oklahoma Gas Corp. Fort Smith, AR
Arkansas Power & Light Co., Hot Springs, AR
  Little Rock, AR

Arkansas Western Gas, Fayetteville, AR
P. E. Barnes Lumber Co., Hamburg, AR
Bibler Lumber, Russellville, AR
J. W. Black Lumber Co., Corning, AR
Boston Edison, Boston, MA
Brabham Tree Planting, Troy, AL
Chem-Air, Inc., Shreveport, LA
Chem-Spray North, Inc., Monroe, LA
Cherry Auto Parts, Waldron, AR
Circle B. Logging, Fordyce, AR
Clarksville Wood Products, Clarksville, AR
Clear Creek Tie Co., Nashville, AR
C & S Lumber Co., Carthage, AR
Curt Bean Lumber Co., Amity, AR
Davis Forestry, Monticello, AR
Deltic Farm & Timber, El Dorado, AR
Dupont Chemical Co., Little Rock, AR
Faust Band Sawmill, Inc., West Helena, AR
Flexsteel Industries, Inc., Harrison, AR
Frazer Inc. Trust, Warren, AR
Georgia Pacific Corp., Crossett, AR;
  Fordyce, AR
Green Bay Packaging, Inc., Morrilton, AR
Griffith Lumber Co., Madison, AR
Hixson Lumber, Pine Bluff, AR
International Paper Co., Arkadelphia, AR;
  Camden, AR; Sheridan, AR; Shreveport, LA
R. A. Kreig & Associates, Inc., Anchorage, AK
Lafayette Timber Co., Stamps, AR
Manville Forest Products, West Monroe, LA;
  Huttig, AR
Mid-South Engineering, Hot Springs, AR
Monsanto Co., Bryant, AR; St. Louis, MO
National Forest Products, Assoc.,
  Washington, DC
Bobby Neill, Consulting Forester,
  Magnolia, AR
Neeley Forestry Service, Camden, AR
Nekoosa Papers, Inc., Ashdown, AR
N.S.I., Inc., Research Triangle Park, NC
Oklahoma Improvement Co., Broken Bow, OK
Ozarks Electric, Fayetteville, AR
Pine Land Corp., Rison, AR
Pomeroy & McGowin, Monticello, AR
Potlatch Corp., Warren, AR
J. P. Price Lumber Co., Monticello, AR
J. A. Riggs Tractor Co., Little Rock, AR
Roberts, Harrell & Lindsay, Camden, AR
Ross Foundation, Arkadelphia, AR
Satterfield Lumber Co., Russellville, AR
Southern Environmental Law Center,
  Charlottesville, VA
H. G. Toler & Sons, Leola, AR

Triplett Timber & Realty, Lewisville, AR
Weyerhaeuser Co., DeQueen, AR
  Eagletown, OK; Hot Springs, AR
Willamette Industries, Inc., Ruston, LA
Wilson Brothers, Rison, AR

Colleges and Universities

Alabama A&M Univ., Normal, AL
Alcorn State Univ., Lorman, MS
Arkansas Tech. Univ., Russellville, AR
Auburn Univ., Auburn, AL
Clemson Univ., Clemson, SC
Delaware State College, Dover, DE
Florida A&M Univ., Tallahassee, FL
Fort Valley State College,, Fort Valley, GA
Harvard Univ. Business School, Boston, MA
Hendrix College, Conway, AR
Humboldt State Univ., Arcata, CA
Kentucky State Univ., Frankfort, KY
Langston Univ., Langston, OK
Louisiana State Univ., Baton Rouge, LA
Mississippi State Univ., Mississippi State, MS
Murray State College, Tishomingo, OK
New Mexico State Univ., Las Creces, NM
North Carolina A&T State Univ., Greensboro, NC
North Carolina State Univ., Raleigh, NC
NSU, Natchitoches, LA
Oklahoma State Univ., Stillwater, OK
Pittsburg State Univ., Pittsburg, KS
Prairie View A&M Univ., Prairie View, TX
Roanoke College, Salem, VA
Rust College, Holly Springs, MS
Slippery Rock State College, Slippery Rock, PA
South Carolina State College, Orangeburg, SC
Southern University, Baton Rouge, LA
Southern Illinois Univ., Carbondale, IL
Stephen F. Austin Univ., Nacogdoches, TX
Tennessee State Univ., Nashville, TN
Texas A&M Univ., College Station, TX
Tuskegee Institute, Tuskegee Institute, AL
University of Alabama, Tuscaloosa, AL
University of Alaska, Fairbanks, AK
University of Arkansas, Pine Bluff, AR;
  Fayetteville, AR; Monticello, AR
University of Central Arkansas, Conway, AR
University of Central Florida, Orlando, FL
University of Florida, Gainesville, FL
University of Georgia, Athens, GA
University of Houston, Clear Lake, TX
University of Kentucky, Lexington, KY
University of Maryland-Eastern Shore,
  Princess Anne, MD

- University of Southern Mississippi,
  Hattiesburg, MS
- University of Tennessee, Knoxville, TN
- University of Wisconsin, Madison, WI
- Virginia State Univ., Petersburg, VA
- VPI & State Univ., Blacksburg, VA
- Western Carolina Univ., Collowhee, NC
- West Georgia College, Carrollton, GA
- West Virginia Univ., Morgantown, WV
- Yale Law School, New Haven, CN

Elected Federal Officials

- Arkansas
  - Dale Bump s
  - David Pryor
  - Bill Alexander
  - Beryl F. Anthony
  - John Paul Hammerschmidt
  - Tommy F. Robinson

- Oklahoma
  - David L. Boren
  - Don Nickles
  - Mike Synar
  - Wes Watkins

Federal Agencies

- Advisory Council Historic Preservation
  Washington DC
- Department of Agriculture
  - APHIS
    - Animal Damage Control, Athens, GA;
    - PPQ, Hyattsville, MD
  - Government & Public Affairs, Washington, DC
  - Horseshoe Bend National Park, Daviston, AL
  - Office of the Secretary, Washington, DC
  - Soil Conservation Service, Fort Worth, TX;
    Little Rock, AR; Mt. Ida, AR; Washington, DC
- Department of Defense
  - Corps of Engineers, Gillham, AR;
    Russellville, AR; Washington, DC
  - Marine Corp Logistic Base, Ft. Gaines, GA
- Department of Health and Human Services
  - CDC, Atlanta, GA
- Department of the Interior
  - Bureau of Land Management, Alexandria, VA
  - Bureau of Mines, Denver, CO; Washington, DC
  - Custom House, Philadelphia, PA
  - Fish & Wildlife Service, Atlanta, GA;
    Annapolis, MD

Geological Survey, Little Rock, AR;
    Tuscaloosa, AL
  National Park Service, Harpers Ferry, WV;
    Louisville, KY; Washington, DC
  Office of Environmental Project Review,
    Albuquerque, NM; Atlanta, GA; Washington, DC
Department of Labor
  Asst. Sec. for Occupational Safety & Health,
    Washington, DC
Department of Transportation
  Asst. Secretary for Policy & International
    Affairs, Washington, DC
  Asst. Secretary for Systems Development,
    Washington, DC
  Federal Highway Admin., Atlanta, GA;
    Baltimore, MD; Baton Rouge, LA; Columbia,
    SC; Fort Worth, TX; Tallahassee, FL;
    Washington, DC
  Federal Railroad Administration, Washington, DC
Environnmental Protection Agency
  Atlanta, GA; Dallas, TX; New York, NY;
  Philadelphia, PA
Equal Employment Opportunity Comm., Washington, DC
Federal Energy Regulatory Comm., Washington, DC
Interstate Commerce Comm., Washington, DC
National Marine Fisheries Serv., St. Petersburg, FL
National Oceanic & Atmospheric Admin. &
  Conservation Div., Washington, DC
Nuclear Regulatory Comm., Atlanta, GA
Rural Electrification Admin., Washington, DC
Small Business Administration, Atlanta, GA
Tennessee Valley Authority
  Golden Pond, KY; Knoxville, TN; Norris, TN

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Anderson, Steven
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Cooper, Jackie & Marsha
Cox, Victor H.
Cristman, Steve
Culver, Eugene
Cumnock, Benjamin H.
Cumnock, Mark J.
Curtner, Tom
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Dalton, Rory
Daniel, Jane Collier
Darby, David F.
Davis, LeRoy
Davis, Okley
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Deaton, Keith
Deer, Noel H.
Dempsey, Joe Paul
Denham, Sam
Dennington, John R.
Derham, Maxine D.
Dodson, Solon L.
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Dressel, Armin T.
Driver, Bill & Karen
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Dunn, Josee D.
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Evans, Sidney H.
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Hoyle, Don D.
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Jones, Robert L.
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Keith, Glen
Kelley, Gordon
Kellison, Robert
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Kessler, George D.
King, Pat
Kinser, Ray
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Mace, Arnett
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Maner, Martin
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Meeks, David E.
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Messling, Gordon L.
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Miller, Patrick
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Morris, Tony
Morrison, Cleo E.
Morrison, Lissa
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Mullens, Bert
Mulligan, William D.
Murphy, Mike & Sherry
Myers, J. Walter, Jr.
Myers, Robert & Delores
Myers, Vernon, Jr.
Nagunst, Melvin
Nance, M. M., Jr.
Narramore, Carolyn
Neary, Dan
Neufville, Mortimer H.
Nichols, Robert
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Oleski, John P.
Owen, Wayne L.
Packee, Edmond C.
Pancholy, Sunil K.
Parsley, Hattie
Pass, Jim
Pebsworth, Clester, H.
Pelech, Walter & Dorothy
Pellham, John T.
Phillips, B. R.
Phills, Bobby Ray
Porter, Christoper S.
Powell, Charles H.
Precure, C. P.
Quertermus, CArl
Ragsdale, E. L.
Rapp, Michael W.
Rawlins, James W.
Regnier, James
Reich, Robert S.
Reinsel, Earl
Rhodes, Robert
Ridgway, Caroll
Ririe, Warren
Ritz, Bob
Robinson, David W.
Robinson, George E., Jr.
Robinson, Jean
Rockwood, Don
Rosamond, Vernon & Velma
Rosene, Marny L.
Rudis, Victor A.
Ruhr, D. L.
Rushing, Jackie L.
Sanchez, James

Sanders, Doug
Sarchez, James
Sawyer, Robert J.
Sawyer, Samuel P.
Schaus, Doug
Schemnitz, S. D.
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Shaw, Carl
Shermer, John
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Simpson, Ocleris
Simpson, R. Alton
Skelton, Walter
Smart, Charles W.
Smethers, Ted W.
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Smith, Leland W.
Smith, Travis
Smithee, Homer
Stalling, Dick
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Stringer, Joe
Strouse, David C.
Summers, Don Russell
Swanson, John R.
Tampkins, Gilbert
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Terrell, Terry
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Thompson, Brian
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Thompson, Don L.
Thompson, Emmett
Thompson, Jesse C.
Thompson, Warren S.
Townsend, Mark
True, M. G.
Van Lear, David
Van Sickle, Charles C.
Vaughn, Leon
Vickers, Larry Gene
Vigerstad, Torgny
Waldrop, Tom
Wales, R. W.
Wallace, Roxana & David
Walker, Joan
Walker, Melvin E., Jr.
Walter, Robert A.
Walterscheidt, Michael
Ward, Fred
Ward, Hal
Warren, Leon
Washburn, Donald J.
Washington, U. S., Jr.
Wasson, Kird D.
Watkins, Marvin H.
Watts, Richard
Waymire, Jackie R.
Weaver, George T.
Webb, Burleigh
Webb, Haul & Sallie
Weber, Wesley
Welch, Mike
Wenner, E. J., Jr.
Westphal, Joanne
White, Danny
White, David E.
White, J. Glen
White, Jack
White, Tim H.
Wickersham, Michael G.
Wiener, Bill, Jr.
Wilks, Glenn R.
Willett, Paul J.
Williams, Don E.
Williams, Robert F.
Williams, Willie F.
Williamson, Handy, Jr.
Williamson, Lionei
Wilson, Charles & Ann
Wilson, Herman
Wood, Kevin
Wright, Keith A.
Wright, Robert D.
Young, Ina
Zeiler, John M.
Zlotsky, Amy

Libraries

Boone County Library, Harrison
Forest Research Library, Mobile, AL
FSL Library, Westvaco, Summerville, SC
INFOSOUTH, Univ. of Georgia, Athens, GA
International Paper Co., Librarian,
  Southlands Experiment Station,
  Bainbridge, GA
Kimberly-Clark Corp. Library,
  Matchitoches, LA
National Agricultural Library,
  Neenah, WI
WESTFORNET, Ft. Collins, CO; Ogden, UT
  Seattle, Washington
Weyerhaeuser Co., Library, Research
  Center, Centralia, WA; Hot Springs, AR

Media

KLYR, Clarksville, AR
Sentinel-Record, Hot Springs, AR
Springfield News-Leader, Springfield, MO
The Heavener Ledger, Heavener, OK

Minority Organizations

Black Chamber of Commerce, Texarkana, TX
Caddo Executive Committee, Binger, OK
Cheyenne-Arapaho Bus. Comm., Concho, OK
Chittimacha Tribal Council, Charenton, LA
Citizen Potawatomi Bus. Comm., Shawnee, OK
Creek National of Oklahoma, Okmulgee, OK
Eastern Bank of Cherokee Indians, Cherokee, NC
Houston Area Urban Leagues, Houston, TX
NAACP, Atlanta, GA; Charleston, SC;
  Columbia, SC; Tallahassee, FL
National Urban League, Inc., Atlanta, GA
NW Univ Center for Urban Aff., Evanston, IL
OIC Opportunity Industrial, Atlanta, GA
OTOE-Missouria Bus. Comm., Red Rock, OK
Pawnee Bus. Council, Pawnee, OK
Quapaw Tribal Bus. Comm., Quapaw, OK
Tonkawa Business Comm., Tonkawa, OK
Urban League of Arkansas, Little Rock, AR

Organizations

American Camping Org., Martinsville, IN
American Forest Council, Atlanta, GA
American Forestry Assoc., Washington, DC
American Motorcycle-Assoc., Westerville, OH

American Orchid Society, Pensacola, FL;
West Palm Beach, FL
American Petroleum Inst., Washington, DC
American Plywood Assoc., Atlanta, GA;
Jackson, MS
American Soc. of Landscape Architects,
Atlanta, GA; Washington, DC
Appalachian Consortium, Inc., Boone, NC
Arkansas Archaeolog. Soc., Arkadelphia, AR
Arkansas Chapter Sierra Club, N. Little Rock, AR
Arkansas Forestry Assn., Little Rock, AR
Chamber of Commerce, Fort Smith, AR
Conservation Education Assoc., Arcata, CA
Corning Wildlife Assoc., Corning, AR
Environmental Law Inst., Arlington, VA
Forester Historical Society, Elkins, AR
Forest Farmers Assoc., Atlanta, GA
Forest Service Timber Purchasers Council,
New Orleans, LA
Institute of Government, Chapel Hill, NC
International Forestsearch LTD,
Prince Albert, Saskatchewan
Izaak Walton League, Arlington, VA
League of Women Voters, Little Rock, AR
Louisiana Forestry Assn., Alexandria, LA
National Assoc. of Conservation Dist.,
Athens, GA
National Forest Products Assoc., Atlanta, GA
Washington, DC
National Wildlife Federation, Washington, DC
National Wild Turkey Fed., Edgefield, SC
Nationwide Forest Planning Clearinghouse,
Eugene, OR
Nature Conservancy, Arlington, VA;
Chapel Hill, NC
Newton County Wildlife Assn., Jasper, AR
Public Awareness Comm., Inc., Fort Smith, AR
SE Assoc. of Fish & Wildlife, Tallahassee, FL
SE Fisheries Council, Fort Collins, CO
Sierra Club Conservation Chair., Fayetteville, AR
Sierra Club Legal Defense, Denver, CO
Sierra Club, SC States Of., Knoxville, TN
Society of American Foresters, Bethesda, MD
Southeast Region of YMCA, Atlanta, GA
Talimena Scenic Dr. Int. Assn., Mena, AR
Tall Timbers Research Station, Tallahassee, FL
Trout Unlimited, Fisherville, VA; Vienna, VA
Wilderness Society, Atlanta, GA
Wildlife Mgmt. Institute, Dripping Springs, TX
WNC Associated Communities, Collowhee, NC
Yale Forest Mgmt. Study Group, New Haven, CT

State and Local Government - Alabama

Forestry Commission, Montgomery
Cooperative Extension Service, Auburn;
  Normal; Tuskegee Institute

State and Local Government - Arkansas

Cooperative Extension Service,
  Little Rock
County Judge, Courthouse, Helena
Dept. of Parks and Tourism, Little Rock
Dept. of Pollution Control, Little Rock
Forestry Commission, Fayetteville;
  Little Rock; Magnolia
Game & Fish Commission, Hot Springs; Lamar;
  Little Rock; Paris; Russellville
Highway & Transportation, Hot Springs
Historic Preservation Prog., Little Rick
Johnson City Quorum Court, Lamar
Mayor, City of Fort Smith
Mayor of Eureka Springs, Eureka Springs
National & Scenic Rivers Comm., Little Rock
Perry Co. Conservation Dist., Perryville
Saline Co. Soil & Water, Benton, AR
State Clearing House, Little Rock

State and Local Government - Florida

Cooperative Extension Service, Tallahassee
Division of Forestry, Tallahassee

State and Local Government - Georgia

Cooperative Extension Service, Fort Valley
Forestry Commission, Macon

State and Local Government - Kentucky

Cooperative Extension Service, Frankfort
Division of Forestry, Frankfort

State and Local Government - Louisiana

Cooperative Extension Service, Baton Rouge
Office of Forestry, Baton Rouge

State and Local Government - Maryland

Cooperative Extension Service, Princess Ann

State and Local Government - Mississippi

Cooperative Extension Service, Lorman
Forestry Commission, Jackson

State and Local Government - New Jersey

Delaware River Basins Commission, West Trenton

State and Local Government - North Carolina

Division of Forest Resources, Raleigh

State and Local Government - Oklahoma

Department of Tranportation, Oklahoma City
Forestry Division, Oklahoma City;
  Talihina
Kiamichi Economic Devel. Dist., Wilburton
Secretary of State, Oklahoma City

State and Local Government - Pennsylvania

DOT, Commonwealth of PA, Franklin

State and Local Government - South Carolina

Commission of Forestry, Columbia

State and Local Government - Virginia

Cooperative Extension Service, Petersburg
Dept. of Forestry, Charlottesville

State and Local Government - Tennessee

Cooperative Extension Service, Nashville
Division of Forestry, Nashville

State and Local Government - Texas

Cooperative Extension Service, Prairie View
Forest Service, College Station

CHAPTER VII

Glossary

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GLOSSARY

Active ingredient (a.i.).--The effective part of a pesticide formulation, or the actual amount of the technical material present in the formulation.

Acute toxicity.--The toxicity of a compound when given in a single dose or in multiple doses over a period of 24 hours or less. The quality or potential of a substance to cause injury or illness shortly after exposure to a relatively large dose.

Adjuvant (additive).--Something added to the pesticide mixture to help the active ingredient do a better job. Examples: wetting agent, spreader, adhesive, emulsifying agent, penetrant.

a.i.--See Active ingredient.

Allelopathic.--Pertaining to the suppression of growth of one plant species by another through the release of toxic substances.

Amine.--Any of a group of organic compounds of nitrogen, such as ethylamine, $C_2H_5NH_2$, that may be considered ammonia derivatives in which one or more hydrogen atoms have been replaced by a hydrocarbon radical.

Animal unit month (AUM).--The amount of feed or forage required by an animal unit for one month.

Annual (plant).--A plant species living and growing for only 1 year or season.

Aquifer.--An underground zone of earth or rock saturated with water whose upper limit is the water table.

AUM.--See Animal unit month.

Biennial (plant).--A plant species that completes its life cycle, from seed germination to seed production, in 2 years. Also means "to occur every 2 years," as in biennial burns.

Bioaccumulation.--The process of a plant or animal selectively taking in or storing a persistent substance. Over a period of time, a higher concentration of the substance is found in the organism than in the organism's environment.

Biological control.--Pest control without the use of chemicals. Parasites, predators, grazing, diseases, etc. are used to control pests.

Biological opinion.--An official report by the Fish and Wildlife Service (FWS) or the National Marine Fisheries Service (NMFS) issued in response to a formal Forest Service request for consultation or conference. It states whether an action is likely to result in jeopardy to a species or adverse modification of its critical habitat.

Biomass.--The total amount (weight) of living material in a given habitat.

Broadcast application.--Uniform distribution of an herbicide over an entire area.

Broadleaf weed.--A nonwoody dicotyledonous plant with wide bladed leaves designated as a pest species in gardens, farms, or forests.

Browse.--That part of leaf and twig growth of shrubs, woody vines, and trees on which browsing animals can feed; to consume browse.

Buffer strip.--A strip of vegetation that is left unmanaged or is managed to reduce the impact that a treatment or action on one area would have on an adjacent area.

Canopy.--The cover of branches and foliage formed collectively by the crowns of adjacent trees and other woody growth.

Carcinogenic.--Producing or inciting cancer.

Chemical degradation.--The breakdown of a chemical substance into simpler components through chemical reactions.

Chronic toxicity.--How poisonous a pesticide is to an animal (or man) after small, repeated doses over a period of time.

Class I area.--One of three classes of areas provided for in the Clean Air Act for the Prevention of Significant Deterioration program. Class I areas are the "cleanest" area and receive special visibility protection. They are allowed very limited increases (increments) in concentrations of regulated pollutants in the ambient air over baseline concentrations. (See 42 U.S.C. 7473 for description of the specific increments).

Conifer.--An order of the Gymnospermae, comprising a wide range of trees, mostly evergreens that bear cones and have needle-shaped or scalelike leaves; timber commercially identified as softwood.

Deciduous.--Pertaining to any plant organ or group of organs that is shed naturally; perennial plants that are leafless for some time during the year.

Diversity.--The distribution and abundance of different plant and animal communities and species within the area covered by a land and resource management plan.

Dose.--The amount of chemical administered or received by an organism, generally at a given point in time.

Drift.--That portion of a sprayed chemical that is moved by wind off a target site.

Duff.--The lower portion of the organic layer covering the soil, consisting of decomposed litter.

Ecological niche.--The physical space in a habitat occupied by an organism; its functional role in a community; and its position in environmental gradients of temperature, moisture, pH, soil, and other conditions of existence.

Ecosystem.--The system formed by the interaction of a group of organisms and their environment.

Ecotone.--The place where plant communities meet or where successional stages of vegetative conditions within plant communities come together; for example, a forest edge.

Edge.--The more or less well-defined boundary between two or more elements of the environment; for example, field/woodland.

Endangered species.--Any species that is in danger of extinction throughout all or a significant part of its range. Endangered species must be designated in the Federal Register by the appropriate Secretary. (See Threatened species.)

Ephemeral stream.--A stream that flows less than 10 percent of the time, only in direct response to rainfall, with a channel that may be scoured or unscoured and is always above the water table.

Ester.--A compound formed by the reaction of an acid and an alcohol, generally accompanied by the elimination of water.

Exposure.--The amount of contact with a pesticide.

FIFRA.--Federal Insecticide, Fungicide and Rodenticide Act (1948, amended 1972, 1975, 1978).

Forage.--All browse and nonwoody plants available to livestock or wildlife for grazing or harvested for feed.

Forb.--Any herbaceous plant other than grass or grasslike plants.

Foreground.--A term used in visual resource management to describe the visible terrain in which individual details of the landscape can be perceived, usually up to 1/4-1/2 mile from the observer.

Formulation.--The form in which a pesticide is packaged or prepared for use. A chemical mixture that includes a certain percentage of active ingredient (technical chemical) with an inert carrier.

Fuel.--Living or dead plant material that will burn.

Habitat.--The natural environment of a plant or animal. An animal's habitat includes the total environmental conditions for food, cover, and water within its home range.

Half-life.--The time required for half the amount of substance (such as a herbicide) in or introduced into a living system to be eliminated whether by excretion, metabolic decomposition, or other natural process.

Hazard.--The risk of danger; the chance that danger or harm will come to the applicator, bystanders, consumers, livestock, wildlife or crops, etc.

Herbaceous.--A plant that does not develop persistent woody tissue above the ground (annual, biennial, or perennial), but whose aerial portion naturally dies back to the ground at the end of a growing season. Herbaceous plants include such categories as grasses, grass-likes (sedges, rushes), and forbs.

Herbicide.--A chemical used to control, suppress, or kill plants, or to severely interrupt their normal growth processes.

Hydrolysis.--Decomposition or alteration of a chemical substance by water.

Inert ingredients.--All ingredients in a forumlated pesticide product which are not classified as active ingredients. Note that inert as used here is a defined usage; many inert products are biologically active chemicals.

Intermittent Stream.--A stream that flows seasonally (10-90 percent of the time) in response to a fluctuating water table, with a scoured channel that is at least 3 feet wide.

Karst.--Topography formed on limestone or other soluble rock and characterized by sinkholes, caves, and underground drainage.

Label.--All printed material on or attached to a pesticide container as required by l[illegible].

Landtype.--A land area with distinct topography, geology, and runoff-erosion response to management.

LC$_{50}$.--See Lethal concentration$_{50}$.

LD$_{50}$.--See Lethal dose$_{50}$.

Lethal concentration$_{50}$(LC$_{50}$).--The concentration of a chemical at which 50 percent of the test animals will be killed. It is usually used in testing of fish or other aquatic animals.

Lethal dose$_{50}$(LD$_{50}$).--Median lethal dose, is the milligram of toxicant per kilogram of animal body weight (mg/kg) lethal to 50 percent of the test animals to which it is administered under the conditions of the experiment.

Median lethal dose, is the milligram of toxicant per kilogram of animal body weight (mg/kg) lethal to 50 percent of the test animals to which it is administered under the conditions of the experiment.

Litter.--The upper portion of the organic layer covering the soil, consisting of unaltered dead remains of plants and animals whose original form is still visible.

Margin of safety (MOS).--The ratio between the animal no observed effect level (NOEL) and the estimated human dose. The larger the MOS, the smaller the estimated human dose and the lower the risk to human health.

Meristem.--The growing point or area of rapidly dividing cells at the tip of a stem, root, or branch.

Microbial degradation.--The breakdown of a chemical substance into similer components by bacteria.

Mitigation Measure.--An action taken to lessen adverse impacts or enhance beneficial effects.

Multiple use.--The management of all the various renewable surface resources of the National Forest System so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; that some lands will be used for less than all of the resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of the uses that will give the greatest dollar return or the greatest unit output.

Mutagenicity.--The capacity of a substance to cause changes in genetic material.

National Environmental Policy Act (NEPA).--Establishes a national policy to encourage productive and enjoyable harmony between man and the environment, to promote efforts that will prevent or eliminate damage to the environment and stimulate the health and welfare of man, to enrich the understanding of the ecological systems and natural resources important to the nation, and to establish a Council on Environmental Quality.

National forest land and resource management plan.--A plan developed to meet the requirements of the Forest and Rangeland Renewable Resources Planning Act of 1974, as amended (95-125, 129, 130). This plan guides all natural resource management activities, and establishes management activities, standards, and guidelines for each national forest.

Natural regeneration.--The renewal of a tree crop by natural means, or without efforts to seed or plant trees. The new trees grow from selfsown seeds or by vegetative means such as root suckers.

NEPA.--See National Environmental Policy Act.

NOEL.--See No-observed-effect-level.

Nontarget.--Any plant, animal, or other organism that a method application is not aimed at, but may acciently be injured by the method.

No-observed-effect-level (NOEL).--In a series of dose levels tested, it is the highest level at which no effect is observed.

Noxious weed.--A plant regulated or identified by law as being undesirable, troublesome, and difficult to control.

Oncogenicity.--Capable of producing or inducing tumors in animals, either benign (noncancerous) or malignant (cancerous).

Opportunity cost.--The net loss, expressed in dollars, resulting from the selection of a less efficient course of action.

Perennial.--A plant species having a lifespan of more than 2 years.

Perennial stream.--A stream that flows year-round (more than 90 percent of the time) with a scoured channel that is always below the water table.

Persistence.--The resistance of a herbicide to metabolism and environmental degradation and thus a herbicide's retention of its ability to kill plants for prolonged periods.

Pesticide.--Any substance or mixture of substances intended for controlling insects, rodents, fungi, weeds, or other forms of plant or animal life that are considered to be pests.

Photodecomposition.--The breakdown of a substance, especially a chemical compound, into simpler components by the action of radiant energy.

Photosynthesis.--Formation of carbohydrates in the tissues of plants exposed to light.

Plant community.--An association of plants of various species found growing together in different areas with similar site characteristics.

Poison.--Any chemical or agent that can cause illness or death when eaten, absorbed through the skin, inhaled, or otherwise absorbed by man, animals, or plants. Note that a substance is a poison or not with respect to specific organisms. Animals safely eat many things which are "poisonous" to humans.

Precommercial thinning.--Cutting in immature stands to improve the quality and growth of the remaining stand. None of the felled trees are extracted and utilized.

Protocol.--see Standard.

Pyrolysis.--Chemical breakdown caused in the process of combustion.

Regeneration.--The renewal of a tree crop whether by natural or artificial means. Also, the young crop itself.

Release and weeding.--All work done to free desirable trees from competition with overstory trees, less desirable trees or grasses, and other forms of vegetative growth. It includes incidental disease control work and release of natural and artificial regeneration.

Residue.--The quantity of a herbicide or its metabolites remaining in or on soil, water, plants, animals, or surfaces.

Rhizomes.--A stem, generally modified for storing food materials, that grows along and below the ground surface and that produces adventitious roots, scale leaves, and suckers irregularly along its length, not just at nodes.

Riparian ecosystem.--A transition between the aquatic ecosystem and the adjacent terrestrial ecosystem which is identified by soil characteristics and distinctive vegetation communities that require free or unbound water.

Risk.--The probability that a substance will produce harm under specified conditions.

Risk analysis.--The description of the nature and often the magnitude of risk to organisms, including attendant uncertainty.

Rotation.--The number of years required to establish and grow a timber crop to a specified condition of maturity. The rotation includes a period for harvesting and stand re-establishment, usually 5 years.

Safety factor.--A factor conventionally used to extrapolate human tolerances for chemical agents from no-observed-effect levels in animal test data.

Scoping.--The process by which significant issues relating to a proposal are identified for environmental analysis. Scoping includes eliciting public comment on the proposal, evaluating concerns, and developing alternatives for consideration.

Sensitive Species.--Those plant and animal species identified by a Regional Forester for which population viability is a concern, as evidenced by: significant current or predicted downward trends in population numbers or density; or significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution.

Shrub.--A plant with persistent woody stems and relatively low growth form; usually produces several basal shoots as opposed to a single bole; differs from a tree by its low stature and nonarborescent form.

Silviculture.--The branch of forestry dealing with the care, development, and reproduction of forest trees or stands of timber.

Site preparation.--The removal of competition (including woody slash) and conditioning of the soil to enhance the survival and growth of seedlings or to enhance the germination of seed.

Snag.--A standing dead tree.

Species (plural: species).--A morphologically, genetically, and ecologically defined biological entity to which a binomial and authority is given; e.g., Potamogeton filiformis Pers., the slender-leaf Potamogeton.

Stand.--Trees that grow in the same location, and which are fairly uniform in type, age and risk classes, vigor, stand-size class, and stocking class. The similarity of these qualities distinguish the stand from adjacent stands that contain trees with different features.

Standard.--A principle requiring a specific level of attainment; a rule to measure against.

Subchronic.--The effects observed from doses that are of intermediate duration, usually 3 months.

Succession.--The progressive development of trees or other plants toward their highest role in their ecology; their climax. The replacement of one forest, or other plants, by others.

Technical chemical or pesticide.--The pesticide as it is first manufactured by the company before formulation. It is usually almost pure.

Teratogenesis.--The development of abnormal structures in an embryo.

Threshold.--A dose or exposure below which there is no apparent or measurable adverse effect.

Threshold limit value (TLV).--The concentration of an airborne constituent to which workers may be exposed repeatedly, day by day, without adverse effect.

Timber stand improvement (TSI).--Activities conducted in young stands of timber to improve growth rate and form of the remaining trees; includes release, understory species control, and precommercial thinning.

TLV.--See Threshold limit value.

Toxicity.--A characteristic of a substance that makes it poisonous.

TSI.--See Timber stand improvement.

Understory (vegetation).--Shade-tolerant plants growing below the canopy of other plants. Usually refers to grasses, forbs, and low shrubs under a tree or brush canopy.

Visual resource.--The composite of basic terrain, geologic features, water features, vegetative patterns, and land-use effects that typify a land unit and influence the visual appeal the unit may have for visitors.

Watershed.--The entire area that contributes water to a stream or lake.

Wetlands.--Those areas that are inundated by surface or ground water often enough to support plants and other aquatic life that requires saturated or seasonally saturated soils for growth and reproduction. Wetlands generally include swamps, marshes, bogs and similar areas such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds.

WSI.--See Wildlife Stand Improvement.

Wildlife Stand Improvement (WSI).--Activities conducted in timber stands to improve conditions for various wildlife species. Includes release and midstory removal.

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CHAPTER VIII

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